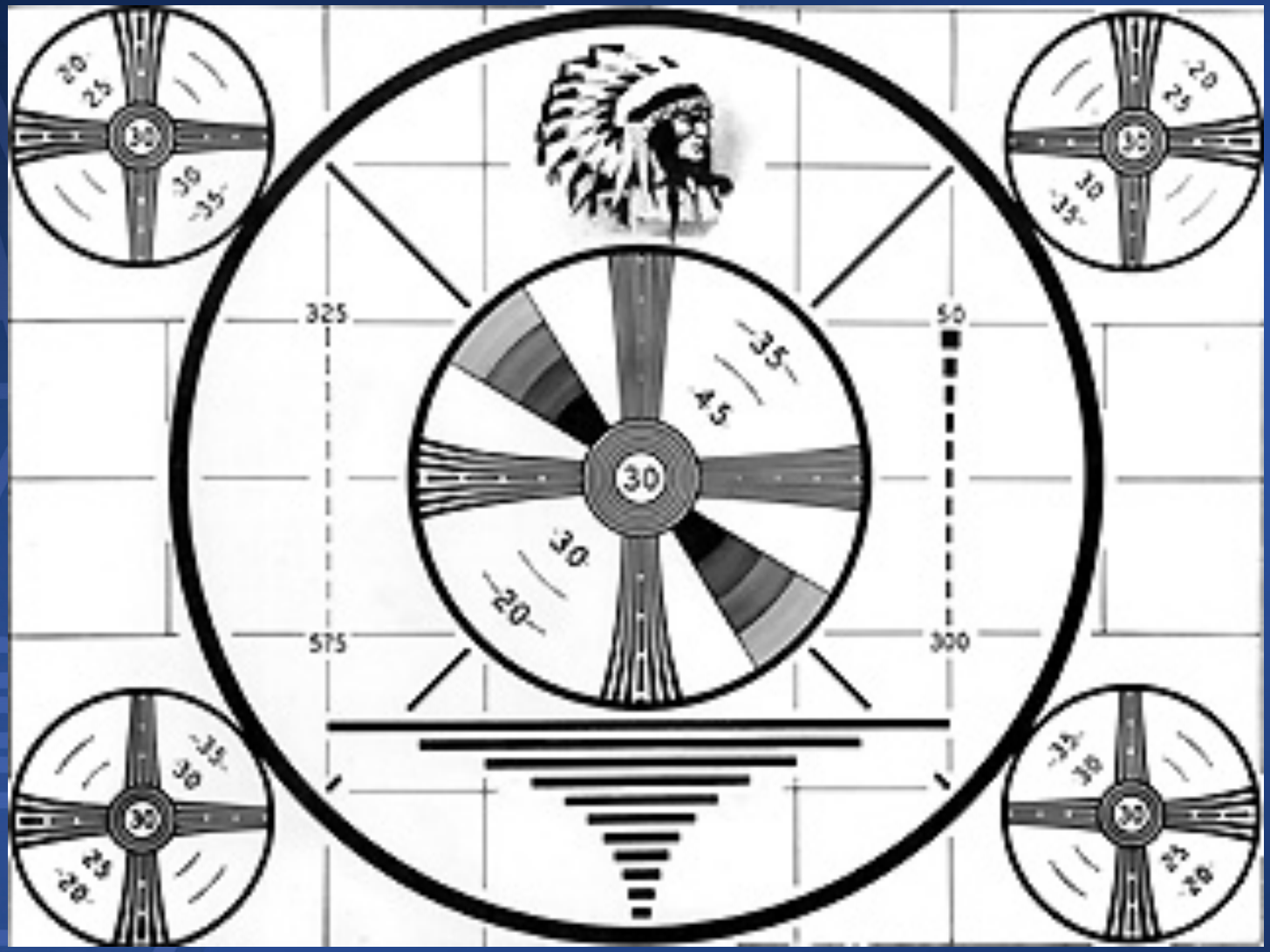

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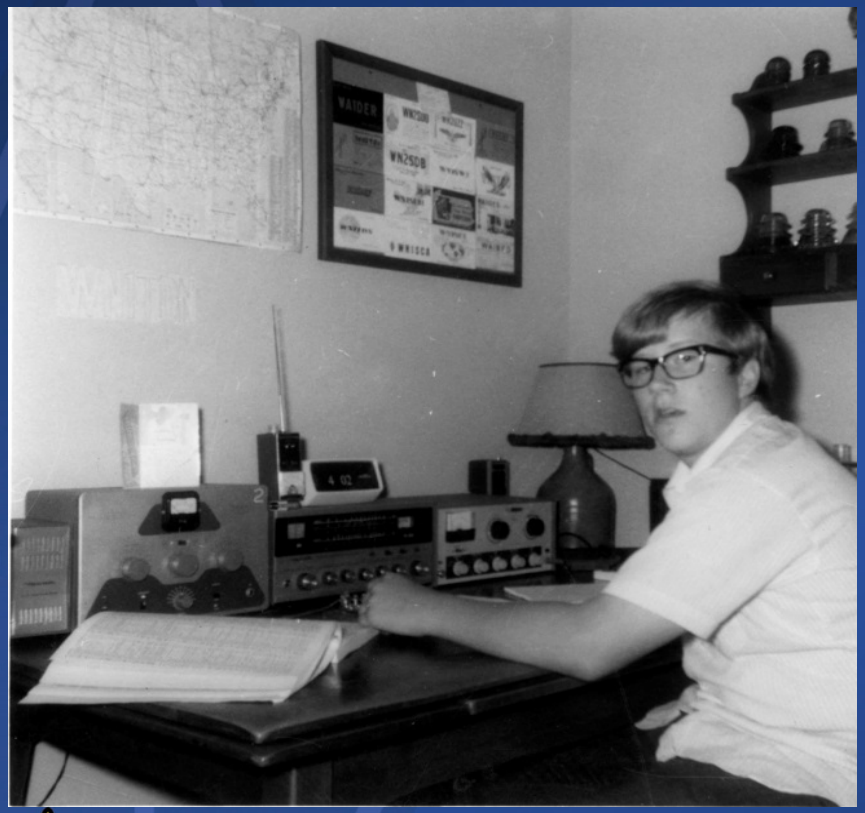
A Look at QST Product Review

Bob Allison, WB1GCM

ARRL Test Engineer

ARRL The national association for AMATEUR RADIO

Hello !



- Bob Allison, WB1GCM
- ARRL Laboratory Assistant Manager & Test Engineer
- Home QTH: Coventry, CT
- Ham since 1974
- University of Hartford
- 28 years TV Engineer
- At ARRL Lab April, 2008
- Kathy, KA1RWY, ARRL Staff Member

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WB1GCM &
KA1RWY
COVENTRY,
CT, FN-31US

ARRL HEADQUARTERS
NEWINGTON, CT

ARRL The national association for AMATEUR RADIO

ARRL
100
Advocacy
Membership
Public Service
Education
Technology

Conducted Emission Test Room

GATES BC-1T 1 KW AM BC TX

- USED AT KPGE, RETIRED IN 1994
- NATIONAL CAPITAL RADIO AND TV MUSEUM
- VINTAGE RADIO AND COMMUNICATIONS MUSEUM OF CT

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MAX

UND. LAB. INC.
CLASS K-5 FUSE

In memory of Bob Rinaldi, WICXY, Simsbury, CT (1941-2017)
GATES
PA PLATE CURRENT
PA PLATE VOLTAGE
MODULATOR
MULTIMETER
Power Switch

ON
ARRL

SKYPE

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W1HQ: ARRL STAFF STATION

Maintained by the ARRL Laboratory

ARRL The national association for AMATEUR RADIO

458 VFO
SIDEBAND SLICER
B
D
AA
AD
C

FRIENDLY ARRL LAB STAFF:

ARRL The national association for AMATEUR RADIO

Lab Manager: Ed Hare, W1RFI
Lab Dad

ARRL The national association for AMATEUR RADIO

Zack Lau
W1VT
Technical Information Service

ARRL The national association for AMATEUR RADIO

Mike Gruber, W1MG
RFI Expert
Retired, October, 2018

ARRL The national association for AMATEUR RADIO

Paul Cianciolo, W1VLF

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QST PRODUCT REVIEW

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The Product Review Process

- Members contact us and request a make and model of Amateur Radio Equipment to Review
- Product Review Editor, Mark Wilson, K1RO and ARRL Editorial Staff choose items that have the most interest
- Equipment is purchased *off the shelf*

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The Product Review Process

Testing

- Each Test follows the ARRL Procedure Manual
- Uniform and consistent testing allow us to directly compare one make and model to another
- Manufacturer is notified if there are issues

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The Product Review Process

When there are issues

- Manufacturer knows what's wrong, long before the review goes to the printer
- We report what was wrong, what modifications were made and how they will modify any units sold
- Manufacturer ends up with a better product!

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What We Test

- HF Transceivers
- VHF/UHF Transceivers
- HF Amplifiers
- Antenna Tuners
- Test Equipment
- Receivers
- Accessories
- My Patience

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We Don’t Test Antennas

(but we do review them)

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WHAT RADIO IS **BEST** ??????????

??????

???

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WE CAN'T TELL YOU,

You Decide!

- (Don't worry, we'll help you!)

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QST Product Reviews Help Radio Amateurs to Decide What to Buy Based On Their Requirements

- The Casual Operator
- The Contest & DX Operator
- The Mobile Operator/Off-Roader
- The “Only Want the Best” Operator
- The “Tight Budget” Operator
- The “Survivor”

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What Features Are Important ?

"Only Wants the Best" Operator"

- Has the money!

"Tight Budget Operator"

- Needs to purchase older, used equipment
- Reads past QST Product Reviews
- (Available on the ARRL Website, 1980 to present)

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What Features Are Important ?

- Casual Operator

  Ergonomics. display, interference and noise rejection

- Contester or DX'er

  Best possible performance, computer control, flexibility, dual receivers, sharp skirted filters

- Mobile/Off Roader

  Small space, detachable control panel, noise rejection

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What Features Are Important ?

"Survivor"

- All Band Radio
- Battery Power; needs low power consumption
- Must be rugged and easily portable
- Vaccum Tube?

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ARRL LAB TESTING

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ARRL LAB
SCREEN ROOM

ABOUT ARRL LAB TESTING:

- A receiver is a box. We send one or more strong signals into the box and observe the undesired effects at the speaker output.
- A Transmitter is a box. We send audio into the box or press a key and observe the undesired effects at the antenna jack.
- ***What is inside the box varies!***

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SDRs and Laboratory Receiver Testing

- Lab testing uses only test signals from signal generators inserted at the antenna jack
- Some test results can be misleading.
- Receiver performance can be mediocre in a lab, but can be significantly better when attached to a high performance antenna.
- Specifically: SDR Receivers

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The Top Receiver Tests:

- Noise Floor (MDS)
- Blocking Gain Compression *Dynamic Range*
- Reciprocal Mixing *Dynamic Range*
- Two-Tone 2nd & 3rd Order IMD *Dynamic Range*
- Audio: THD at 1 V rms

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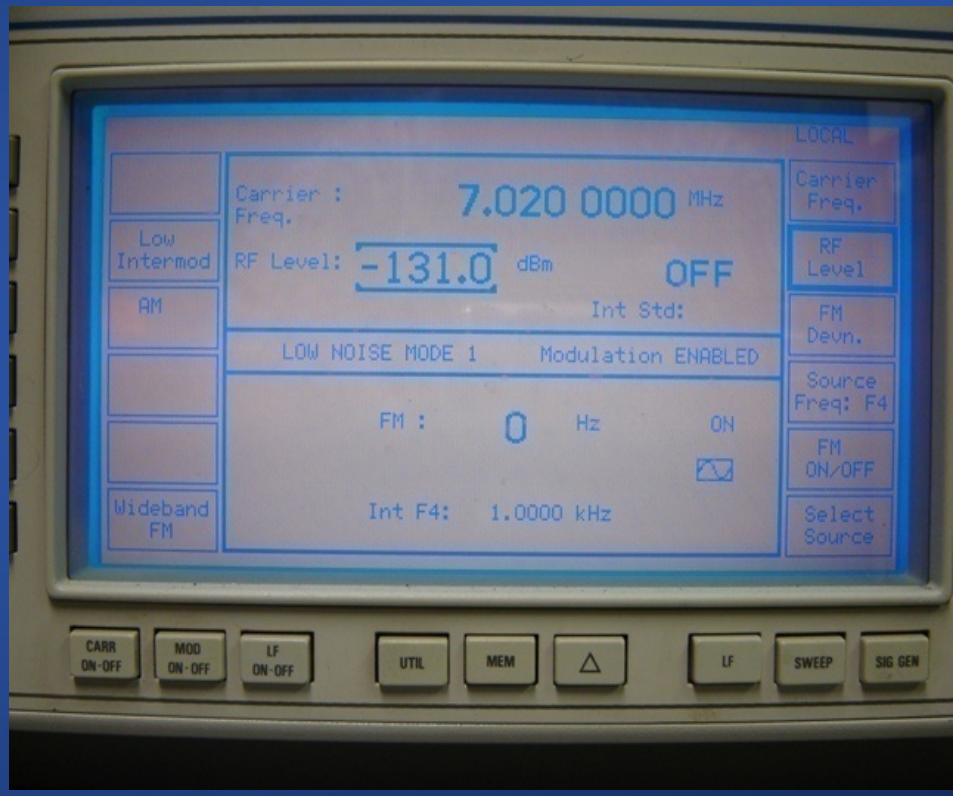
Minimum Discernible Signal

- Known as Noise Floor
- CW, 500 Hz bandwidth
- An audio signal 3 dB above the background noise level

- Typically –120 to –140 dBm



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339A DISTORTION MEASUREMENT SET

HEWLETT • PACKARD

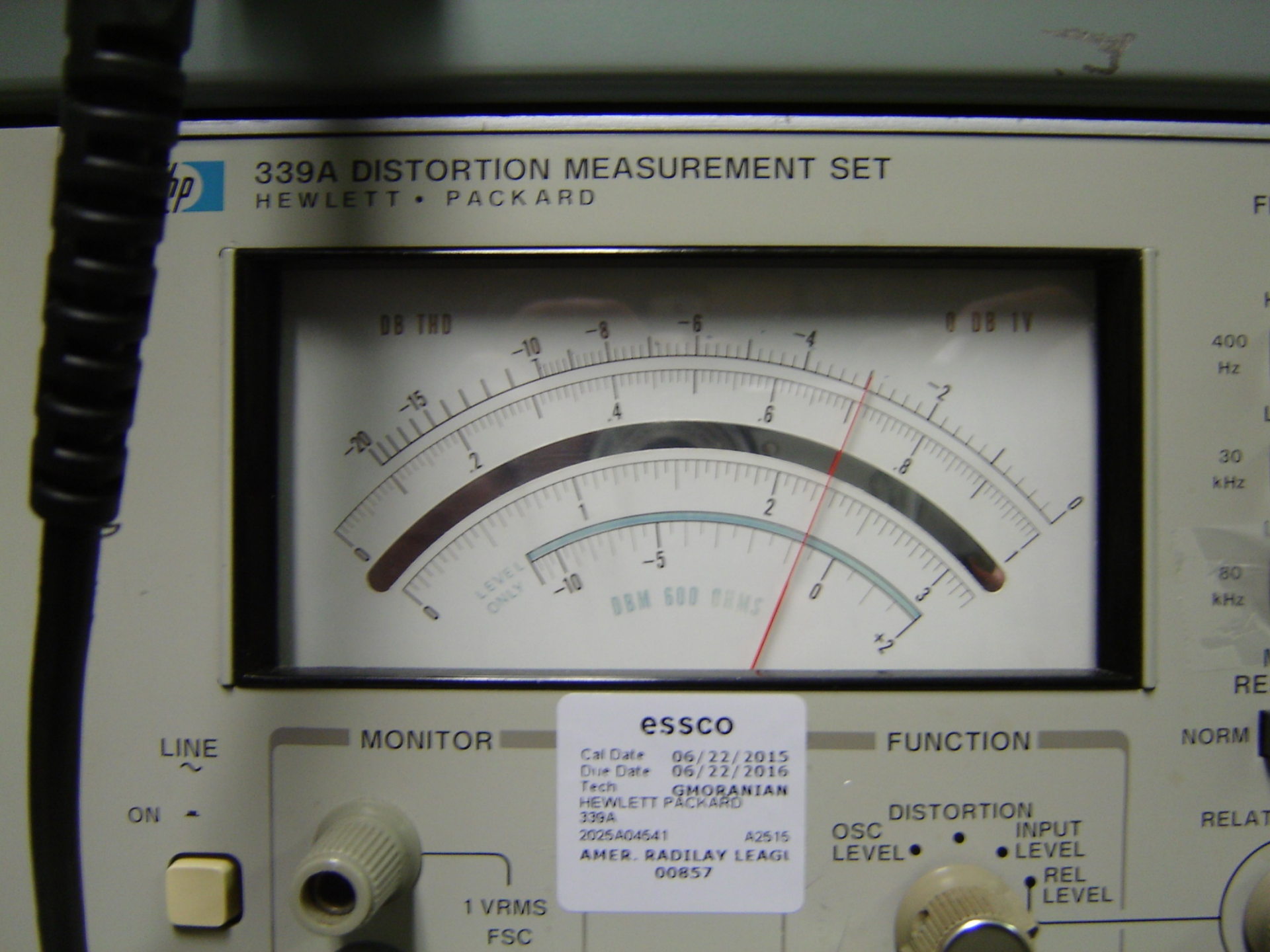
MONITOR

FUNCTION

DISTORTION

essco

Cal Date 06/22/2015
Due Date 06/22/2016
Tech GMORANIAN
HEWLETT PACKARD
339A


339A DISTORTION MEASUREMENT SET
HEWLETT • PACKARD
DB THD
0 DB 1V
LEVEL ONLY
DBM 600 OHMS
essco
Cal Date 06/22/2015
Due Date 06/22/2016
Tech GMORANIAN
HEWLETT PACKARD
339A
2025A04541 A2515
AMER. RADILAY LEAGI
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MONITOR
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FSC
FUNCTION
DISTORTION
OSC LEVEL
INPUT LEVEL
REL LEVEL
NORM
RELAT
400 Hz
30 kHz
80 kHz

Minimum Discernible Signal

- Very Sensitive: Less than -140 dBm
- Good Sensitivity: -130 dBm
- Fair Sensitivity: -120 dBm
- -110 dBm……could be better!

BUT……

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Hook up an Antenna….

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Minimum Discernible Signal

- With Antenna Connected:
- Receiver hears: Atmospheric Noise, Solar Noise and Man-Made Noise.
- Noise Floor is Raised
- Receiver with -120 dBm Sensitivity hears about as well as the receiver with -140 dBm Sensitivity!
- Directly relates to receiver dynamic range

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RECEIVER DYNAMIC RANGES

- A Dynamic Range is the range of input signal levels (in dB) at the antenna jack without unwanted effects
- Dynamic Range is the MDS level (weakest signal) up to a higher input signal level that causes unwanted effects in the speaker
- MDS level – off channel signal level(s) = DR
- The ARRL Lab measures three dynamic ranges

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RECEIVER DYNAMIC RANGES

- Two-tone Third Order Intermodulation Distortion Dynamic Ranger (3 IMD DR)
- Reciprocal Mixing Dynamic Range (RM DR)
- Blocking Gain Compression Dynamic Range (B DR)

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Two-Tone Third-Order IMD Dynamic Range

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Two-Tone Third-Order IMD Dynamic Range

- IMD: Inter-modulation Distortion

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Two-Tone Third-Order IMD Dynamic Range

- IMD: Inter-modulation Distortion
- Two strong, evenly spaced, adjacent signals mixing together which creates a "*phantom*" signal on the desired frequency

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Two-Tone Third-Order IMD Dynamic Range

- IMD: Inter-modulation Distortion
- Two strong, evenly spaced, adjacent signals mixing together which creates a "*phantom*" signal on the desired frequency
- Created in amplifier or mixing stages of a superhetrodyne receiver, or in the preamp or filter stage prior to the ADC in an SDR.

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Two-Tone Third-Order IMD Dynamic Range

- IMD: Inter-modulation Distortion
- Two strong, evenly spaced, adjacent signals mixing together which creates a "*phantom*" signal on the desired frequency
- Created in amplifier or mixing stages of a superhetrodyne receiver, or in the preamp or filter stage prior to the ADC in an SDR.
- Number of bits used in ADC; 16 bit is best

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Two-Tone Third-Order IMD Dynamic Range

- IMD: Inter-modulation Distortion
- Two strong, evenly spaced, adjacent signals mixing together (called, “the IMD Signal”)
- 20 & 40 kHz (20 kHz spacing)
- 5 & 10 kHz (5 kHz spacing)
- 2 & 4 kHz (2 kHz spacing)
- MDS level – IMD level = 3 IMD DR

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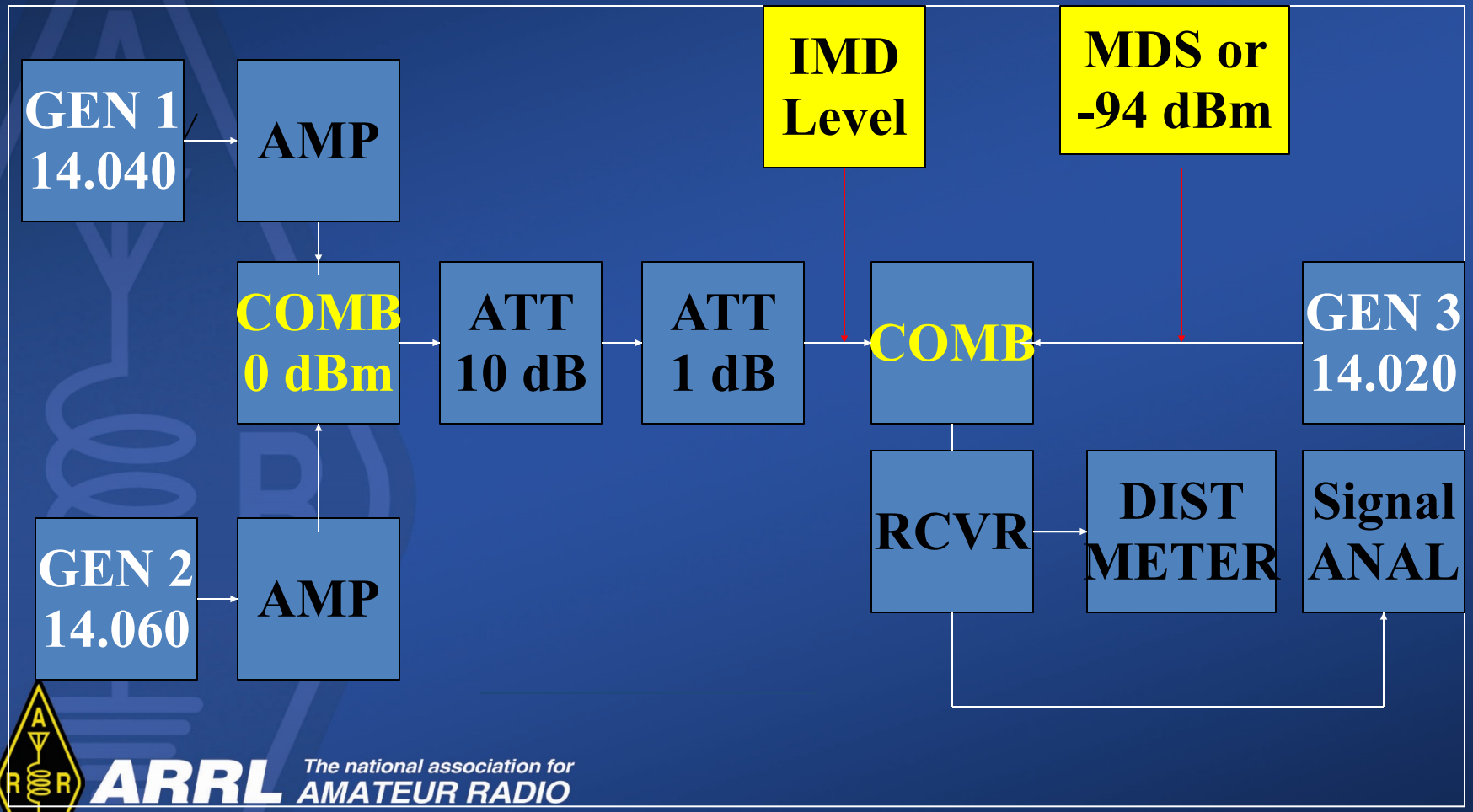
Two-Tone Third-Order IMD Dynamic Range Hook-up



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PowerSDR v2.7.2 FLEX-5000: 5107-5294
Memory Wave Equalizer XVTRs CWX Mixer Antenna ATU FlexControl ESC Get Help Heros About
VFO A
14.008 500
20M Extra CW
TX
VFO Sync
VFO Lock
Tune Step
500Hz
7.000000
Save
Restore
VFO B
14.008 500
TX
20M Extra CW
13.980.0
13.990.0
14.000.0
14.010.0
14.020.0
14.030
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-29102.4Hz -3.96dBm 13.979.998 MHz
Pan
Center
Zoom
0.5x
1x
2x
4x
SPLT
A>B
A<B
A<>B
XIT 0
RIT 0
VAC1
VAC2
NR
ANF
NB
NB2
SR
BIN
Panadapter
AVG
Peak
TNF
+TNF
MultiRX
Swap
Speed: 25 WPM
Pitch Freq (Hz):
Iambic
Sidetone
Show TX CW Frequency
Break In
Enabled
Delay (ms):
300
Pan
VOL
Mute
AGC-T: 75
SQL: -104
AGC:
Med
LSB
USB
DSB
CWL
CWU
FM
AM
SAM
DIGL
DIGU
DRM
16k
12k
10k
8.0k
6.6k
5.2k
4.0k
Var 1
Var 2
Low
-4000
High
4000
FlexRadio Systems™
SAMSUNG

SDRs and Two-Tone Third-Order IMD Dynamic Range

- Band conditions have an effect on some software defined receivers.
- On a dead band, the 3 IMD DR may be mediocre. When hooked up to an antenna during good conditions, 3 IMD DR can increase.
- A single, strong off channel signal can increase 3 IMD DR (ARRL Lab discovery; Feb, 2010 QST)
- We report “Up to XX dB” for 3 IMD DR and include a footnote of 3 IMD DR during quiet conditions.

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Two-Tone Third-Order IMD Dynamic Range

Top Receivers:

- **100 to 110 dB with 20 kHz spacing**
- **100 dB with 2 kHz spacing**
- **Can be the most limiting of the three dynamic ranges in an SDR receiver**

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Reciprocal Mixing Dynamic Range

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Reciprocal Mixing Dynamic Range

- Caused by the first LO sideband (phase) noise mixing with a strong adjacent incoming signal which increases receive background noise in a superhetrodyne receiver

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Reciprocal Mixing Dynamic Range

- Caused by the first LO sideband (phase) noise mixing with a strong adjacent incoming signal which increases receive background noise in a superhetrodyne receiver
- Determined by the spectral purity of the ADC clock in an SDR.

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Reciprocal Mixing Dynamic Range

- Caused by the first LO sideband (phase) noise mixing with a strong adjacent incoming signal which increases receive background noise in a superhetrodyne receiver
- Determined by the spectral purity of the ADC clock in an SDR.
- SDRs can exhibit no reciprocal mixing up the point of ADC overload

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Reciprocal Mixing Dynamic Range

- A single, off channel, strong signal that increases the background noise.
- Measurements made with off channel signal at 20, 5 & 2 kHz away from the tuned frequency
- Off channel signal is raised until a 3 dB increase of background noise is observed
- MDS level – Off Channel level = RM DR

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Wenzel Low Noise Test Oscillator

Reciprocal Mixing Dynamic Range

- A Top Receiver:
- 120 dB at 20 kHz spacing
- 100 dB at 2 kHz spacing

- NOTE: Reciprocal mixing can be the most limiting dynamic range of the three dynamic ranges in a Superhetrodyne receiver

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Blocking Dynamic Range

- A signal which is reduced by the presence of a strong, off channel (blocking) signal
- Blocking signal level is raised until a 1 dB drop of speaker audio is observed
- MDS level – Blocking signal level = B DR

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Blocking Dynamic Range

- A Top Receiver:
- 120 to 140 dB
- Some software defined receivers exhibit little or no blocking effects from strong adjacent signals up to the point of overload
- Reciprocal Mixing can make this measurement difficult with Superhetrodyne receivers

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Blocking Dynamic Range

- Measurements are performed with a single blocking signal……What about multiple blocking signals?
- Some SDRs have proved susceptible to blocking from multiple strong signals at the antenna jack
- ARRL Lab is developing a new test using multiple blocking signals
- IC-7610 vs IC-7300
- IC-7610 has an automatically tuned pre-selector that attenuates out of band signals

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Dynamic Range: SDR vs Superhet

We have three DYNAMIC RANGES

Pick the LOWEST of the three Dynamic Ranges at 2 kHz SPACING

THE LOWEST of the three Dynamic Ranges IS THE DYNAMIC RANGE

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Dynamic Range: SDR vs Superhet

- SDRs have higher RM DR & B DR
- Superhets can have higher 3 IMD DR, but SDRs are catching up
- SDRs keep improving!

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Top Performers Considering *Lowest Dynamic Range* at 2 kHz Spacing

• Yaesu FTdx101D	110 dB (IMD)
• Icom IC-7851	105 dB (IMD)
• Elecraft K3S	104 dB (IMD)
• Yaesu FTdx-5000	104 dB (RM)
• FlexRadio 6600M	104 dB (IMD)
• Icom IC-7610	101 dB (IMD)
• Elecraft KX3	100 dB (IMD)
• Icom IC-7300	100 dB (IMD)

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Yaesu FTdx-5000D:

EVEN A TOP PERFORMING TRANSCEIVER CAN HAVE A SIGNIFICANT FAULT

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5
10
15
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200
P
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ID
1.5
2
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5
50
∞
SWR
ALC
V
VDD
HF/50MHz TRANCEIVER
TUNE
RX — ANT — 1-

AUDIO: TOTAL HARMONIC DISTORTION

- Audio distortion causes operator fatigue during long operating events
- Most THD specs are at 10% and at maximum volume (who listens at that level?)
- ARRL measures THD at 1 V rms, a typical listening level.
- THD best if below 1%

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DO I NEED TOP PERFORMANCE?

- **Only if you have a high performance antenna system (need all three dynamic ranges to be high), or**
- **If you have another transmitter near your location operating on the same Amateur band (Reciprocal Mixing and/or Blocking Gain Compression DR)**

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“I ONLY HAVE A G5RV ANTENNA”

- There is no need for high performance since not enough signal voltage reaches the antenna jack. An entry level transceiver will perform just fine
- Exceptions: Close “Big Gun”, or Field Day setups operating different modes on the same band
- SOLUTION: USE A BAND PASS FILTER

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“ALL I HEAR IS NOISE AND SLOP!”

- Turn off the preamp
- Turn on the attenuator and adjust until the unwanted effect is reduced or eliminated
- CW: Turn off the AGC and ride the RF gain

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ADVICE

- Perfect your antenna system before buying an RF amplifier
- If you can't hear them, you can't work them!

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Transmitter Testing

Receiver Performance Has Improved; How About Transmitter Performance?

Not as much as we would like !

REMEMBER: The best receivers cannot remove transmitted splatter, key clicks, wide keying sidebands and high transmit phase noise.

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Receiver Performance Has Improved; How About Transmitter Performance?

Not as much as we would like !

- Transmit IMD can be poor, causing splatter
- Keying Sidebands can be wide, taking up more spectrum
- High Phase Noise adds to background noise, masking weak signals

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The Top Transmitter Tests

- Output Power
- Spectral Purity
- Transmit Two-tone IMD
- Keying Sidebands
- CW Keying Waveform
- Phase Noise

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Spectral Purity

- The FCC requires minimum bandwidth necessary for information rate and emission type.
- Must not cause splatter or key clicks

43 dB below fundamental below 30 MHz

60 dB below fundamental 30-225 MHz for transmit power ≥ 25 Watts

or 25 uV max spurious/harmonic output

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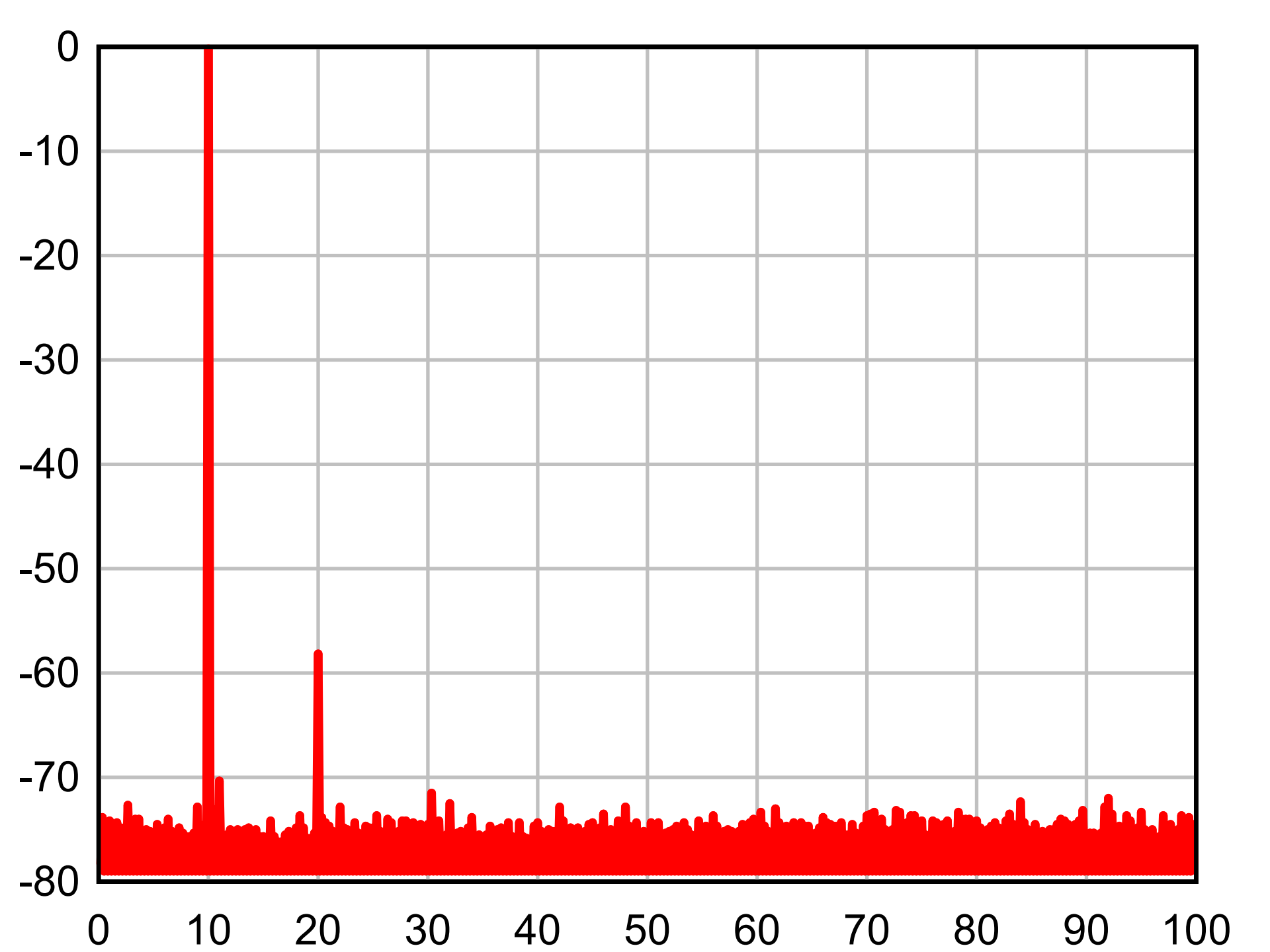
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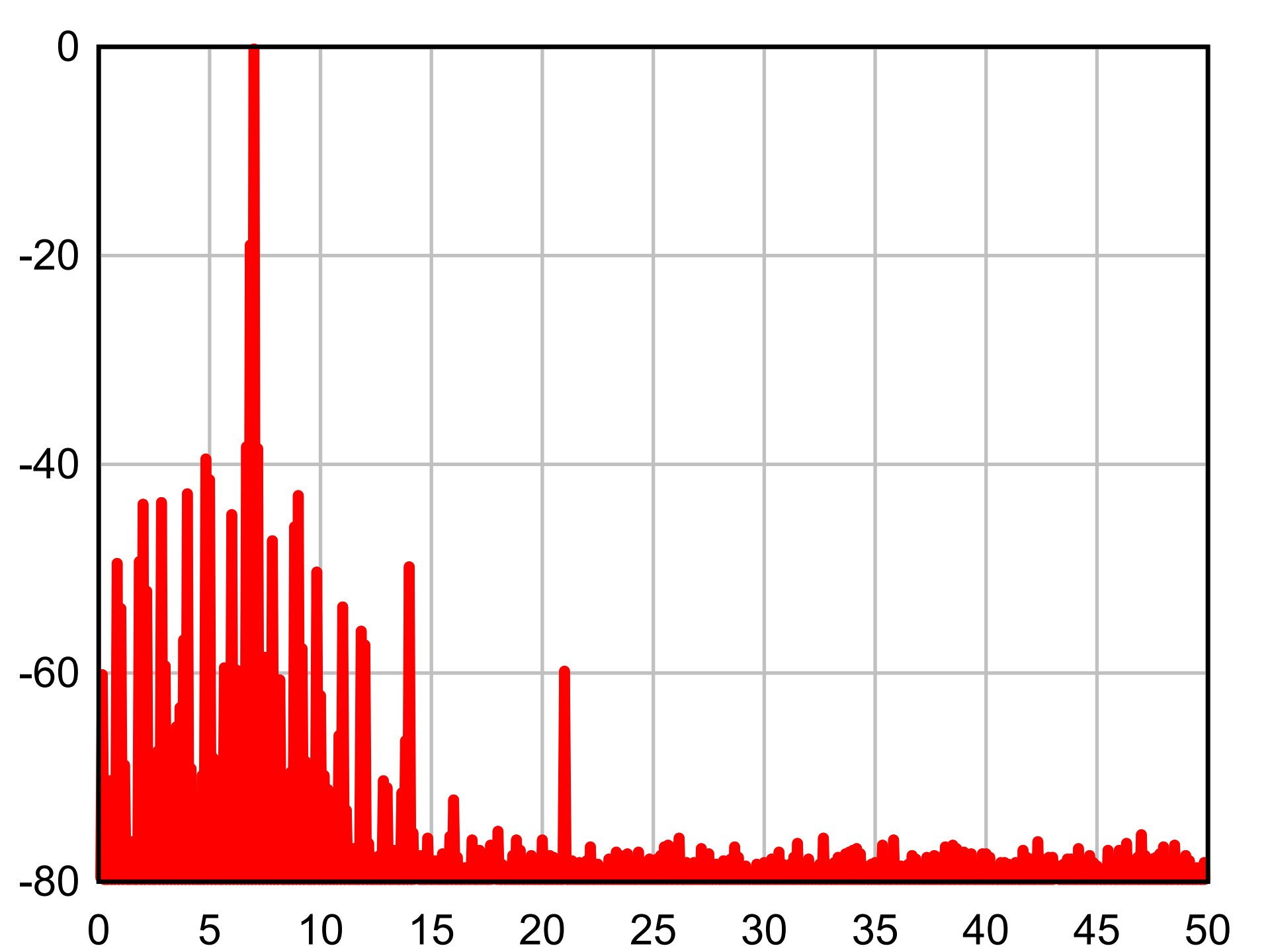
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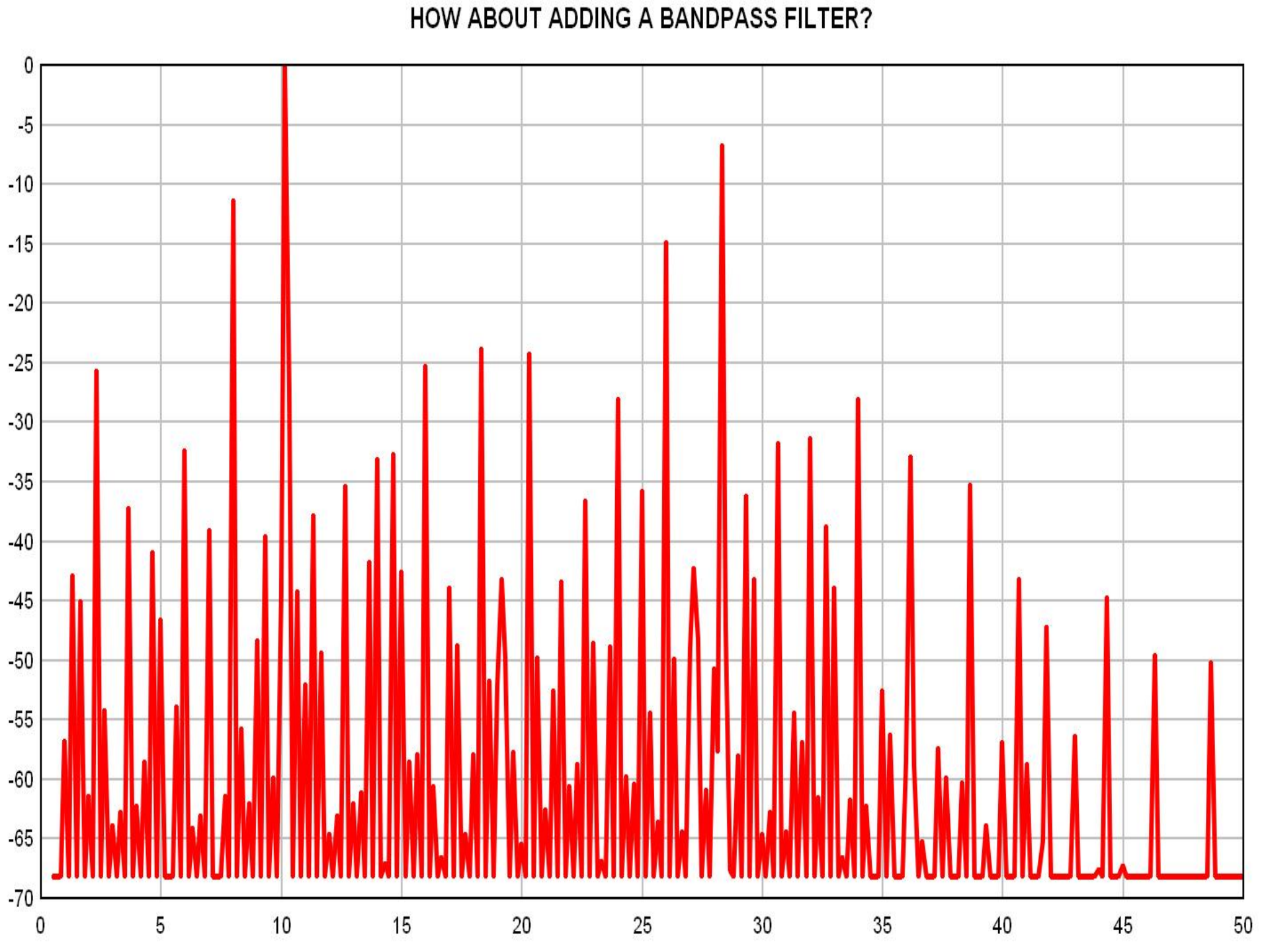
HOW ABOUT ADDING A BANDPASS FILTER?
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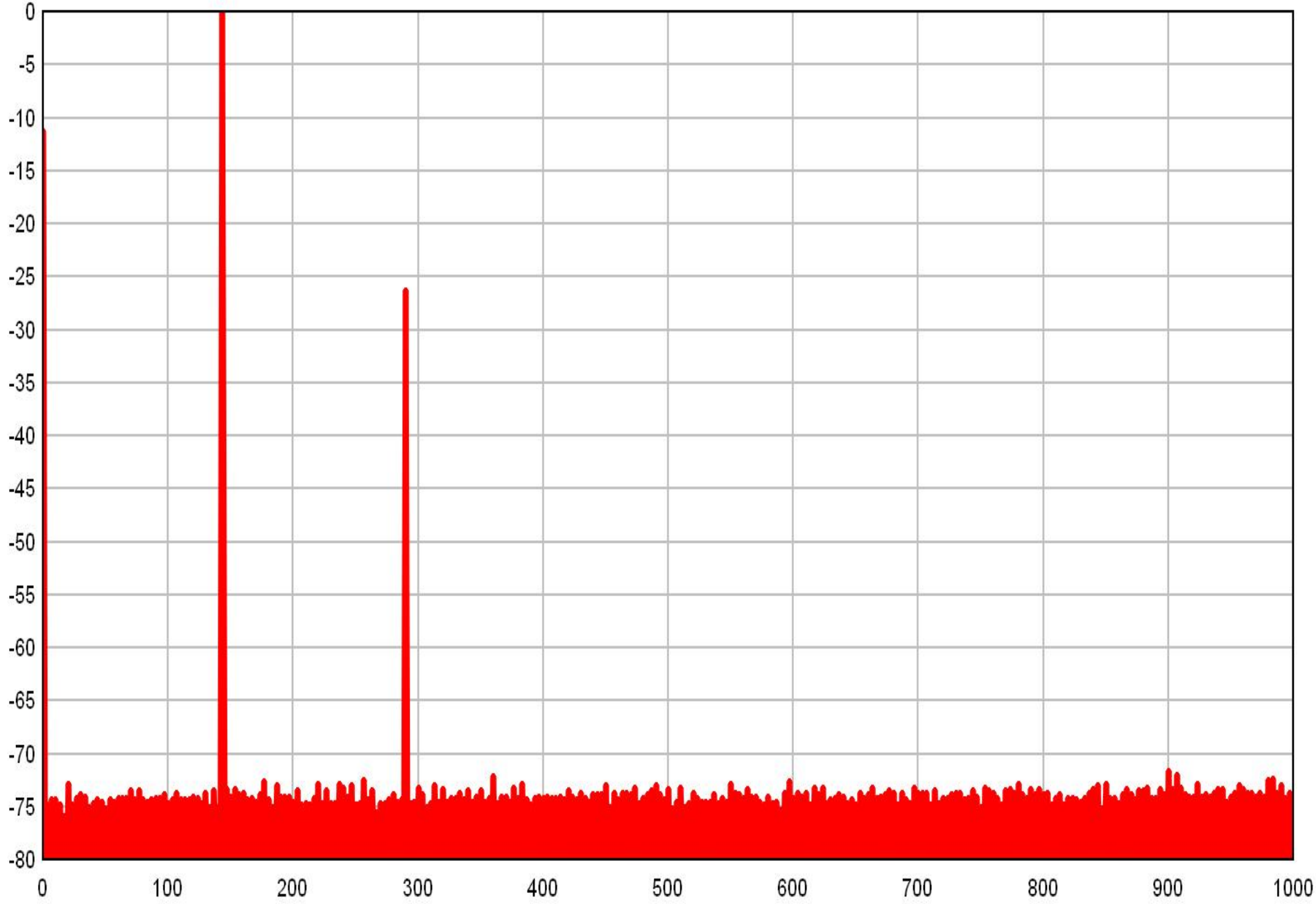
Baofeng UV-3R, 2nd Unit

Ist Harmonic at -26 dBc; Fails FCC Part 97 Spurious Emission Levels



NOVEMBER 2015 QST PAGE 74-76

Table 1
ARRL Laboratory Testing of Handheld Transceivers at Conventions

Year	Units Tested	Compliant	Borderline	Noncompliant
2012	129	91%	3%	6%
2013	244	87%	4%	9%
2014	282	76%	8%	16%
2015	264	80%	7%	14%

Table 2
ARRL Laboratory Testing of Handheld Transceivers by Manufacturer

2012 Manufacturer	Units Tested	Compliant	Borderline	Noncompliant
Yaesu	54	100%	0%	0%
Wouxun	16	100%	0%	0%
Kenwood	15	100%	0%	0%
Icom	14	100%	0%	0%
Baofeng	13	31%	15%	54%
TYT	6	50%	17%	33%
Other	11			

2013 Manufacturer	Units Tested	Compliant	Borderline	Noncompliant
Yaesu	67	99%	0%	1%
Icom	47	100%	0%	0%
Baofeng	41	49%	15%	36%
Kenwood	40	100%	0%	0%
Wouxun	26	77%	4%	19%
Motorola	6	100%	0%	0%
RadioShack	5	100%	0%	0%
Other	12			

2014 Manufacturer	Units Tested	Compliant	Borderline	Noncompliant
Yaesu	90	100%	0%	0%
Baofeng	67	10%	33%	57%
Kenwood	47	98%	0%	2%
Icom	37	100%	0%	0%
Wouxun	15	67%	0%	33%
RadioShack	6	100%	0%	0%
Motorola	5	100%	0%	0%
Connect Systems	5	100%	0%	0%
Other	10			

2015 Manufacturer	Units Tested	Compliant	Borderline	Noncompliant
Yaesu	69	100%	0%	0%
Baofeng	65	25%	21%	54%
Icom	53	100%	0%	0%
Kenwood	27	100%	0%	0%
Wouxun	22	86%	0%	14%
Connect Systems	8	100%	0%	0%
Other	20			

Specific makes and models in which the majority of the units tested were noncompliant:
Baofeng, UV5R, UV5R+, UV5RA, UV5RE, UV5RT, UVB5, UV82X, UV-B6, BF-F8HP, GT3; F-11, E-5 MKII, UV-3R (older units, pre 2013)
Wouxun, KG-UVD1P (2 m / 220 MHz), KGUV3D (2 m / 220 MHz)
TYT, TH-UV3R (2 m / 220 MHz), TH-UVF9 (2 m / 220 MHz)
Handhelds of "Other" Manufacturers numbered less than 5 units of each model and therefore, a reasonable sample of each model was not available.

ARRL The nat AMA

TECH CORR2 - Windows Photo Viewer
File Print E-mail Burn Open

Icom	37	100%	0%	0%
Wouxun	15	67%	0%	33%
RadioShack	6	100%	0%	0%
Motorola	5	100%	0%	0%
Connect Systems	5	100%	0%	0%
Other	10			

2015

Manufacturer	Units Tested	Compliant	Borderline	Noncompliant
Yaesu	69	100%	0%	0%
Baofeng	65	25%	21%	54%
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Other	20			

Specific makes and models in which the majority of the units tested were noncompliant:
Baofeng, UV5R, UV5R+, UV5RA, UV5RE, UV5RT, UVB5, UV82X, UV-B6, BF-F8HP, GT3; F-11, E-5 MKII, UV-3R (older units, pre 2013)
Wouxun, KG-UVD1P (2 m / 220 MHz), KGUV3D (2 m / 220 MHz)
TYT, TH-UV3R (2 m / 220 MHz), TH-UVF9 (2 m / 220 MHz)
Handhelds of "Other" Manufacturers numbered less than 5 units of each model and therefore, a reasonable sample of each model was not available.

Transmit Two-Tone IMD

- Measures transmitted spurious output close to the desired transmitted audio
- Measured in SSB mode.
- Created by the audio stages or any amplification stage
- Made worse by the operator exceeding the ALC limit (too much mic & processor gain)
- Test performed using two tones into mic input

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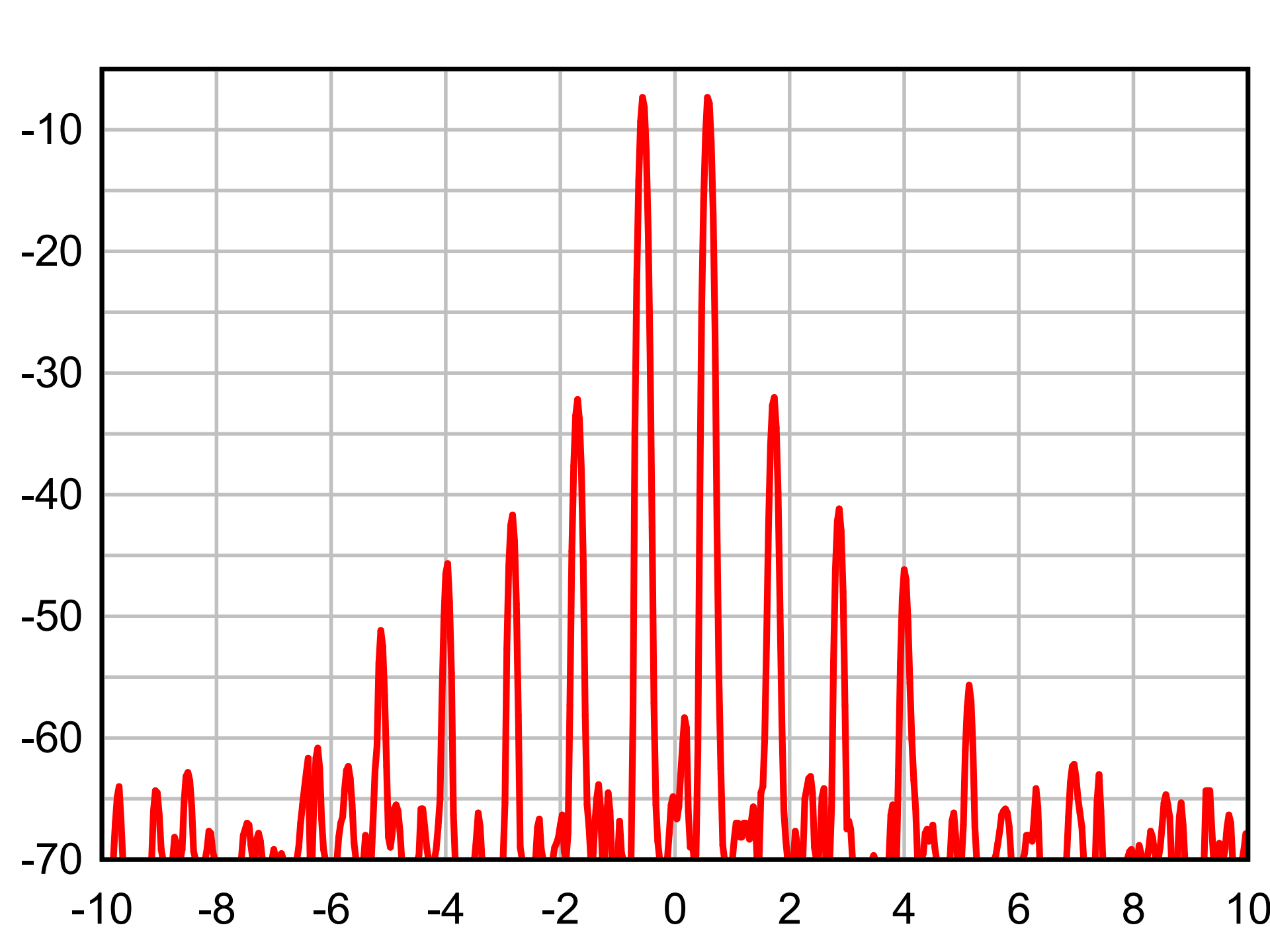
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-50
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-10
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-6
-4
-2
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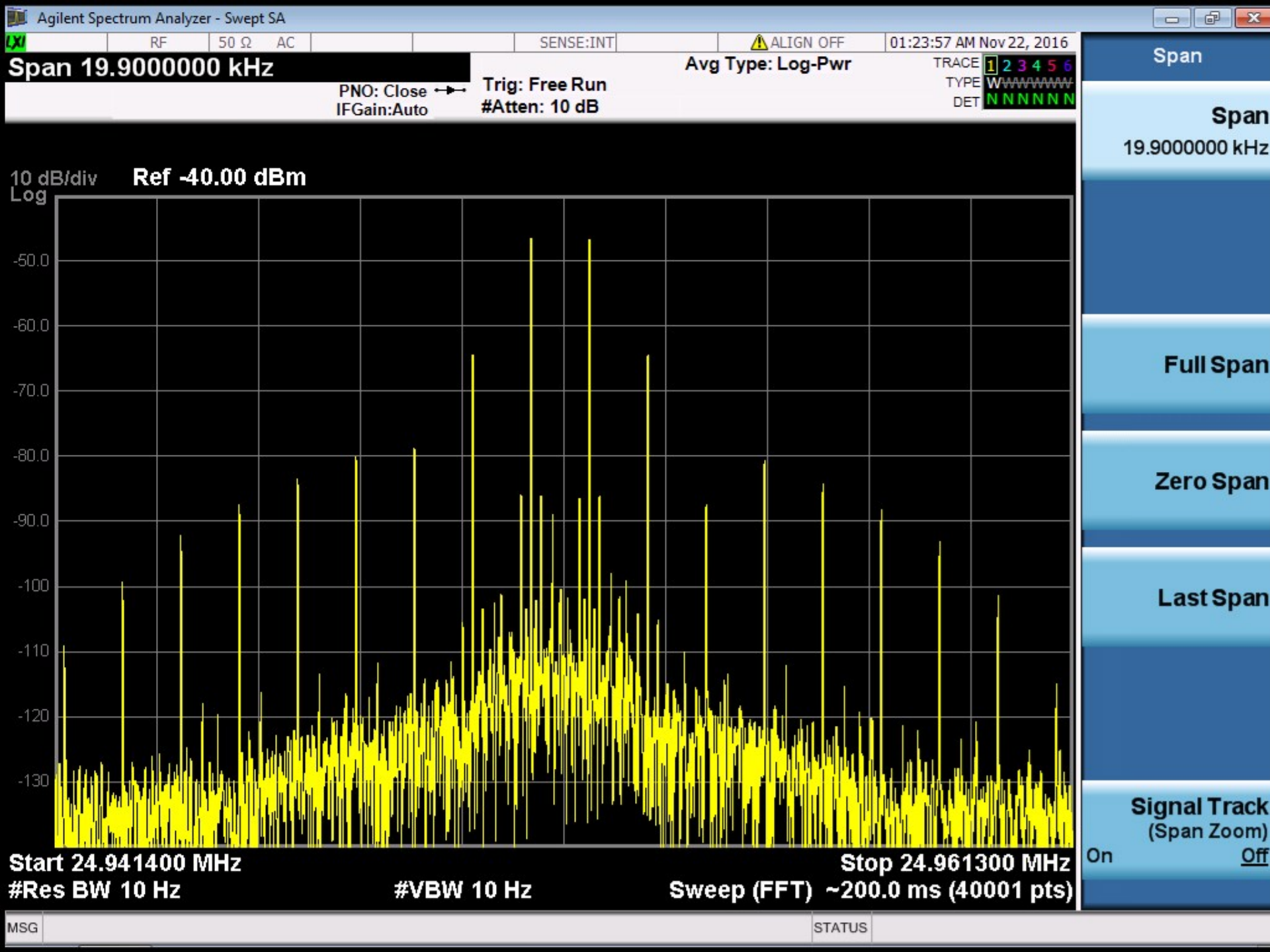
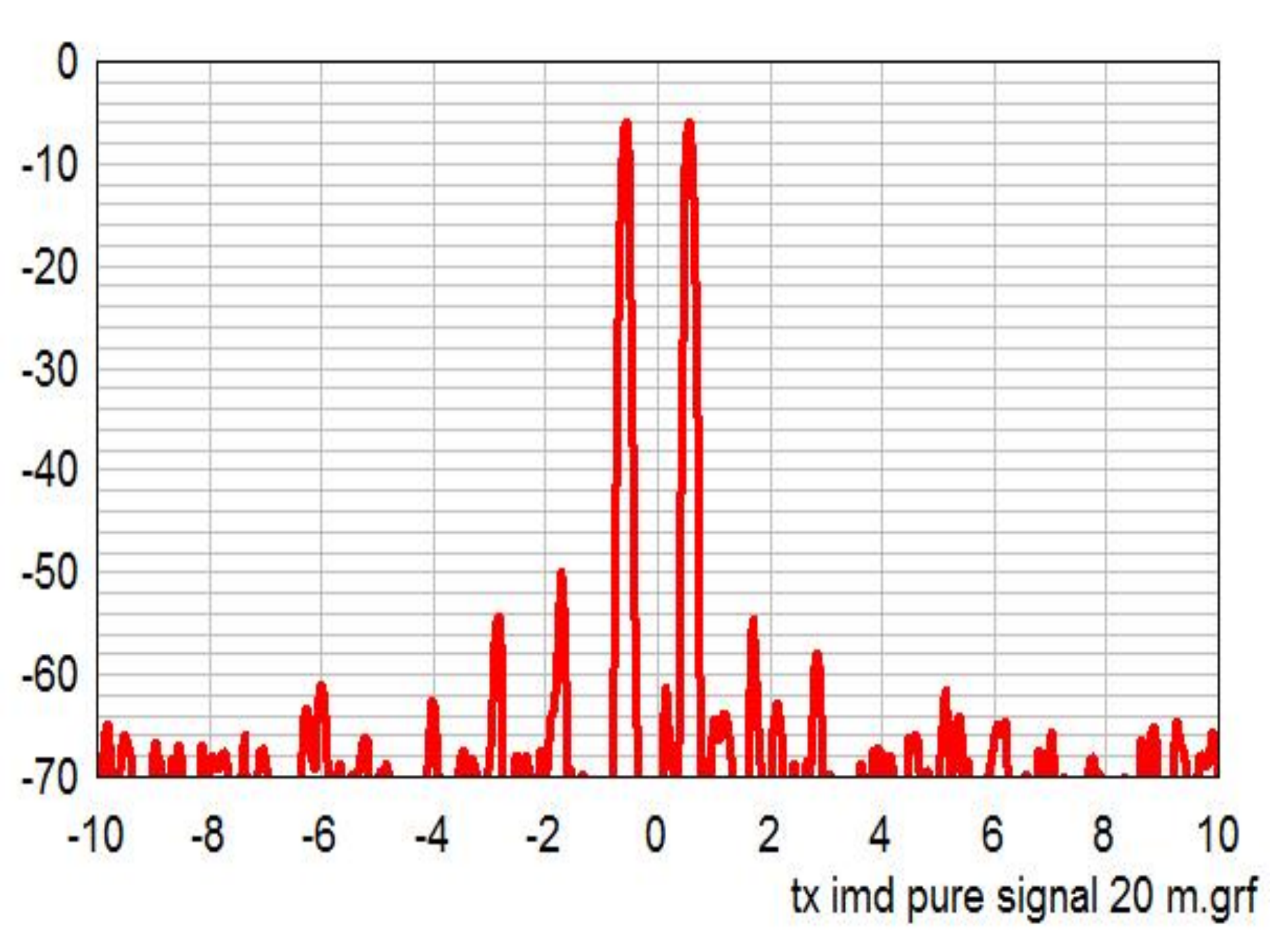
2
4
6
8
10


Agilent Spectrum Analyzer - Swept SA
RF
50 Ω AC
SENSE:INT
ALIGN OFF
01:23:57 AM Nov 22, 2016
Span 19.9000000 kHz
PNO: Close
IFGain:Auto
Trig: Free Run
#Atten: 10 dB
Avg Type: Log-Pwr
TRACE 1 2 3 4 5 6
TYPE WWWWW
DET N N N N N
10 dB/div
Log
Ref -40.00 dBm
-50.0
-60.0
-70.0
-80.0
-90.0
-100
-110
-120
-130
Start 24.941400 MHz
#Res BW 10 Hz
#VBW 10 Hz
Stop 24.961300 MHz
Sweep (FFT) ~200.0 ms (40001 pts)
Span
Span
19.9000000 kHz
Full Span
Zero Span
Last Span
Signal Track
(Span Zoom)
On
Off
MSG
STATUS


0
-10
-20
-30
-40
-50
-60
-70
-10
-8
-6
-4
-2
0
2
4
6
8
10
tx imd pure signal 20 m.grf

Keying Waveform

- String of dits at 60 WPM
- First and second dit captured on oscilloscope
- Dit shortening on QSK
- Key clicks
- Keying delay
- ALC Overshoot

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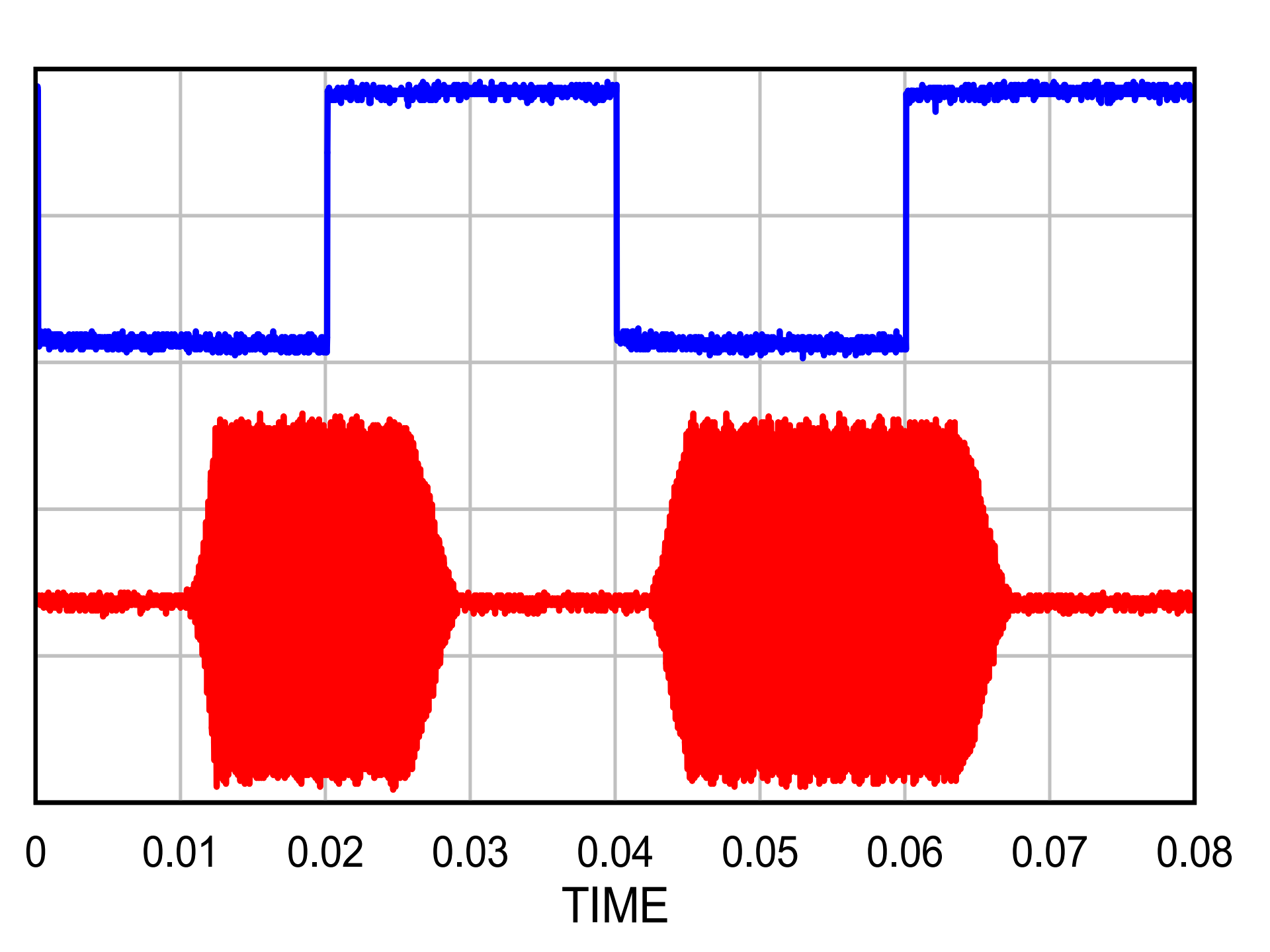
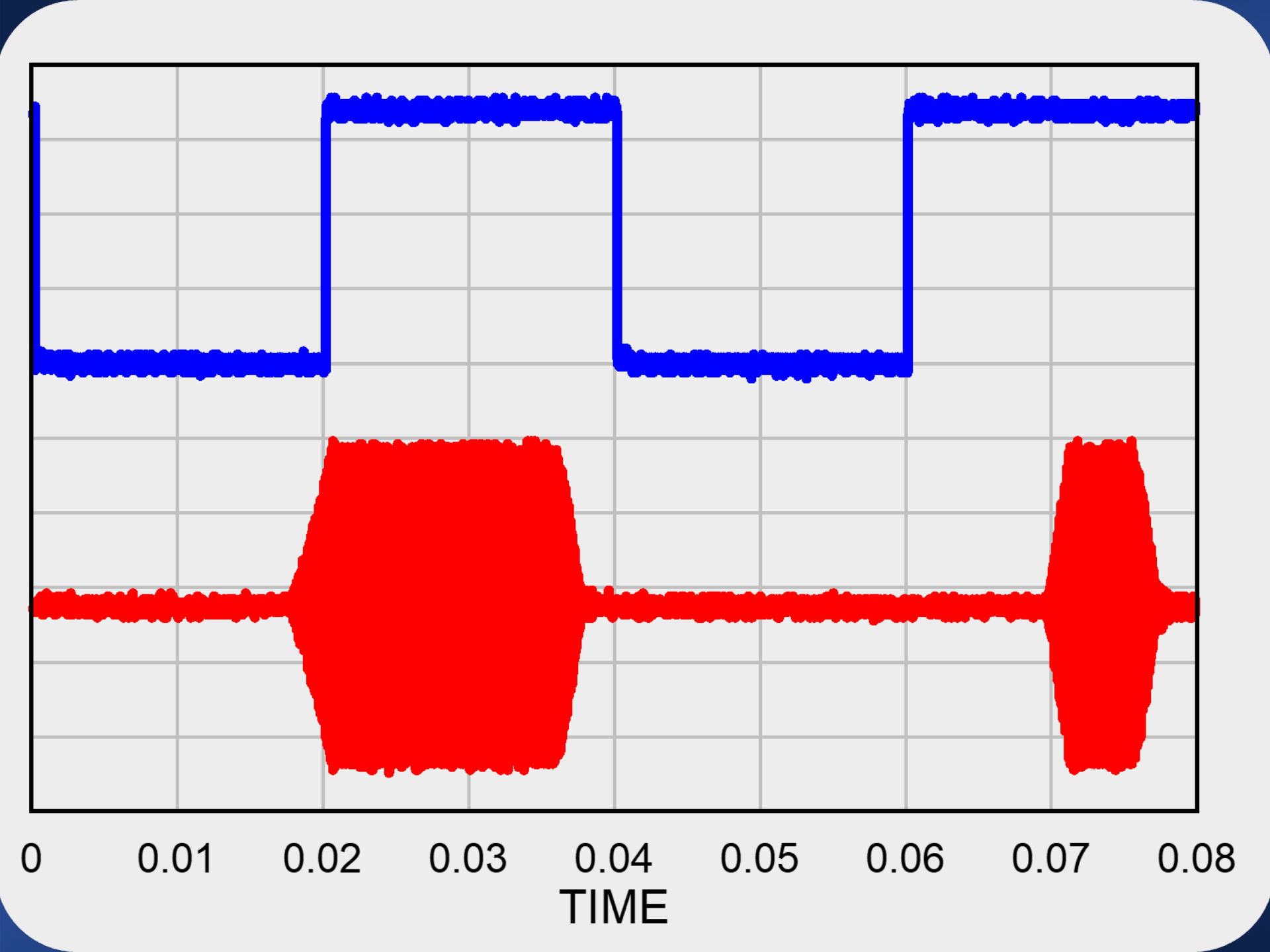
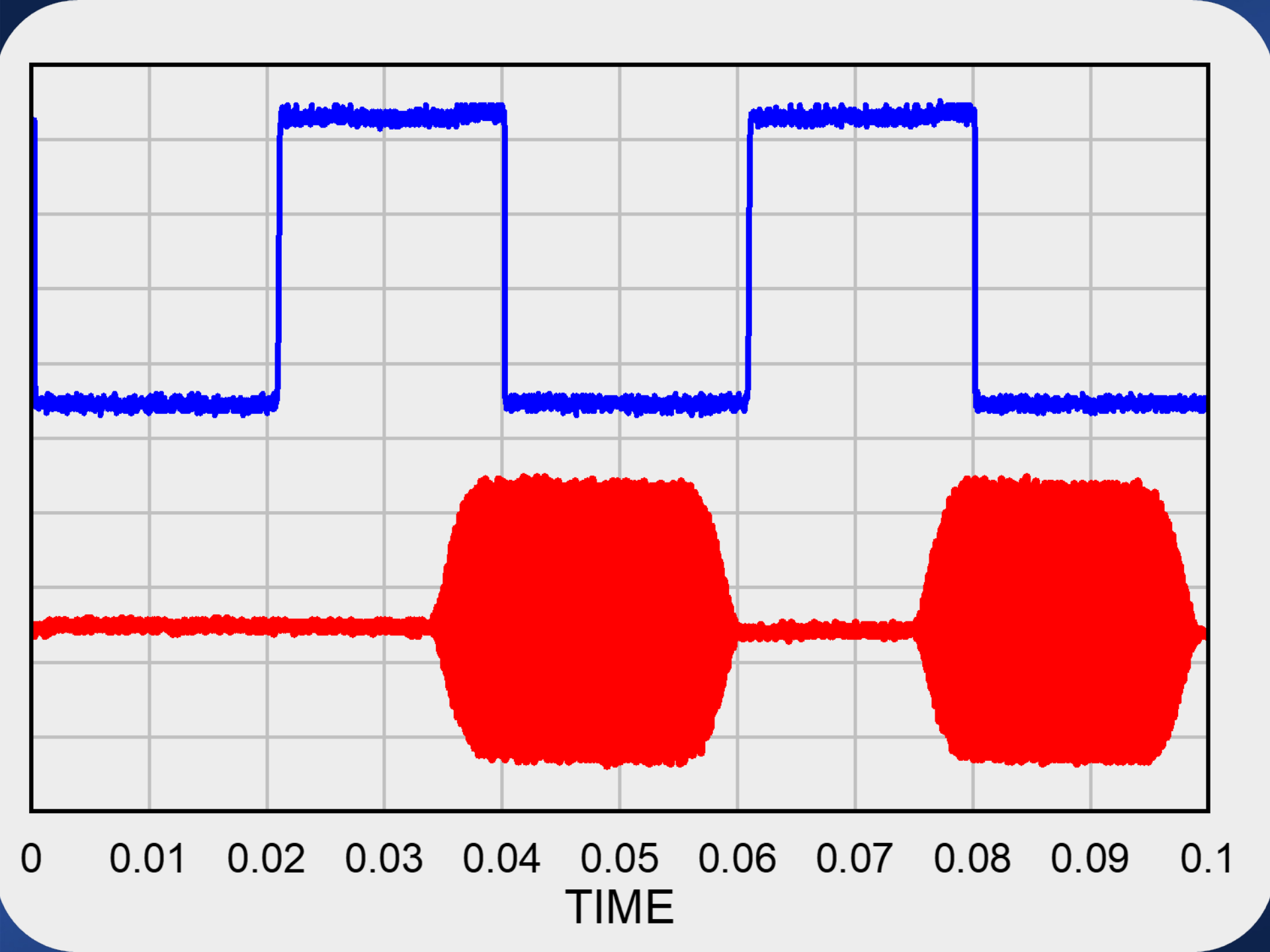

0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
TIME


0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
TIME


0
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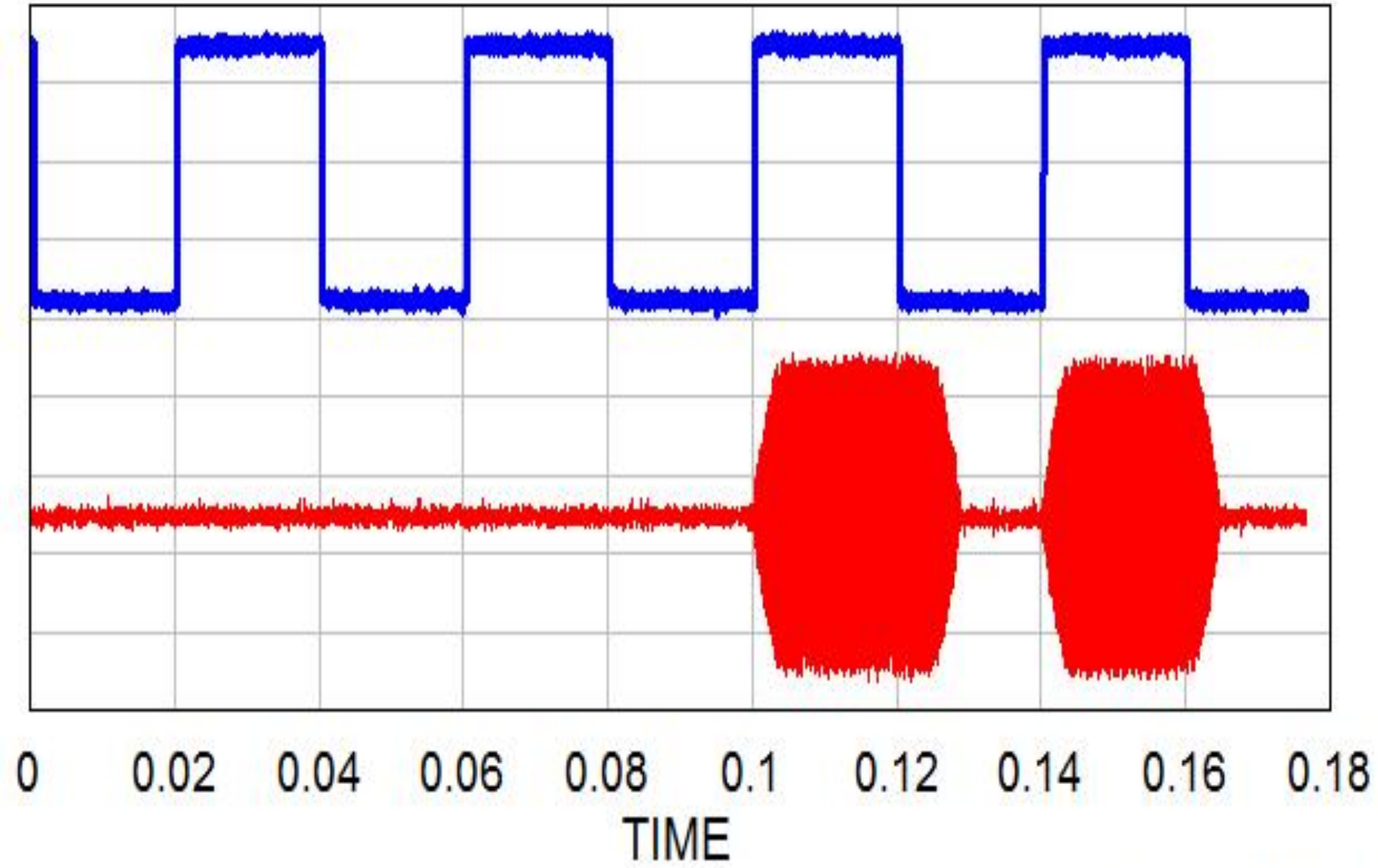
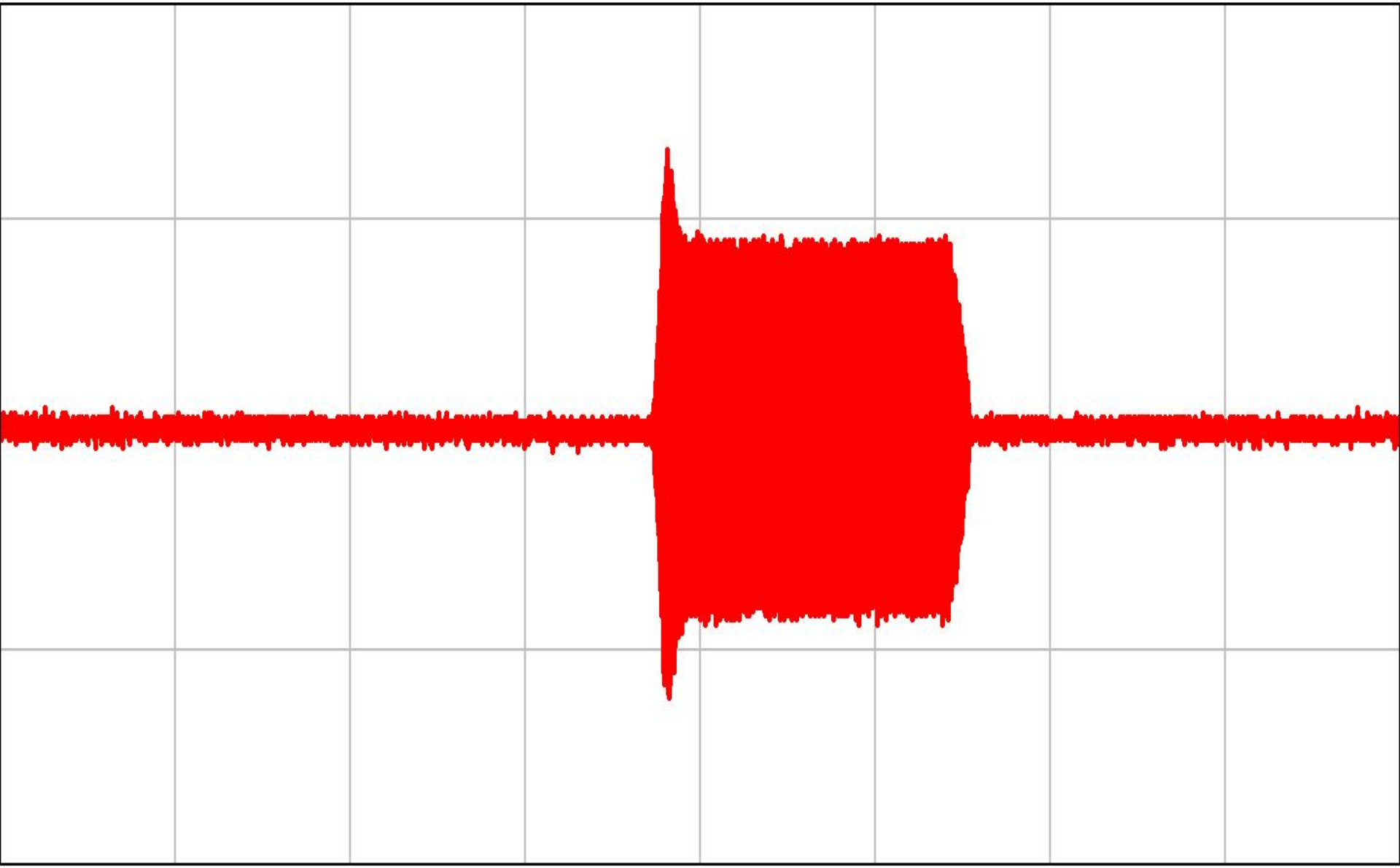
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
TIME


0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
TIME
keying waveform1500.grf

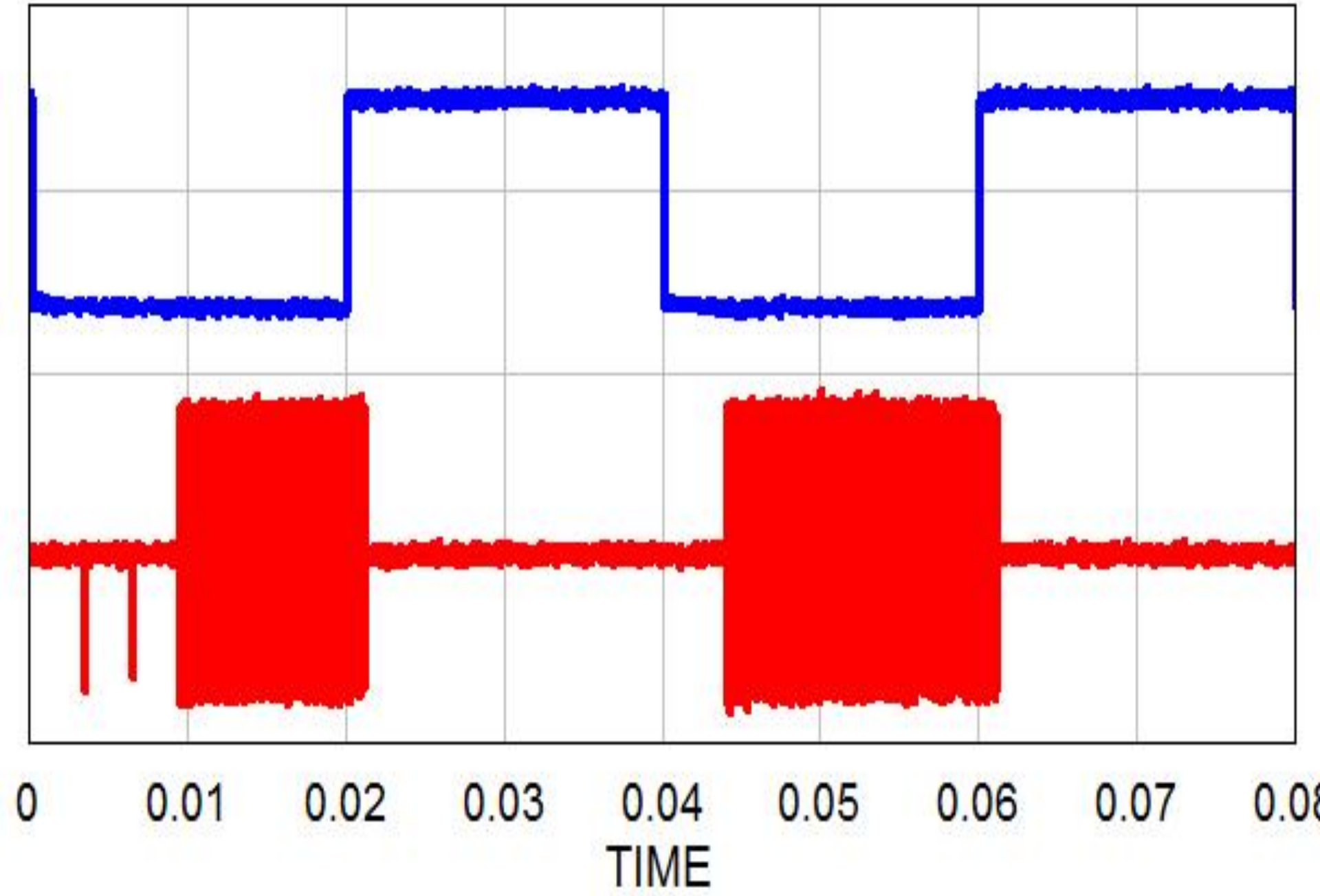
Alinco DX-SR9T

Low Power

Overshoot On Leading Edge of Dit



TIME


0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
TIME

Keying Sidebands

- CW Dits at 60 WPM
- Spectrum Analyzer Bandwidth at 10 Hz
- Sweep Time at 30 Seconds
- Keying Waveform Rise and Fall Time:
- Little or no rise and fall time has the most effect on the CW sidebands

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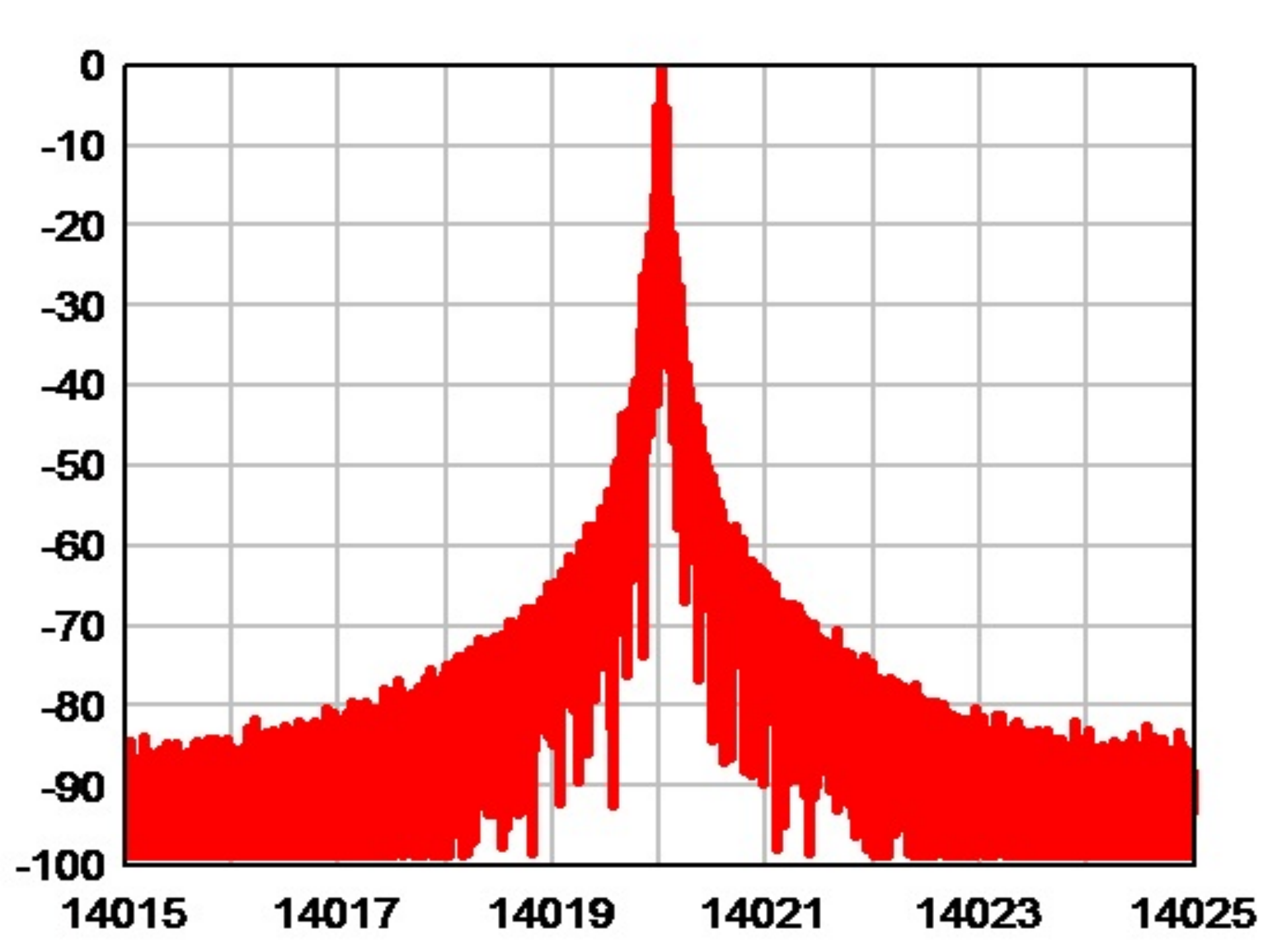
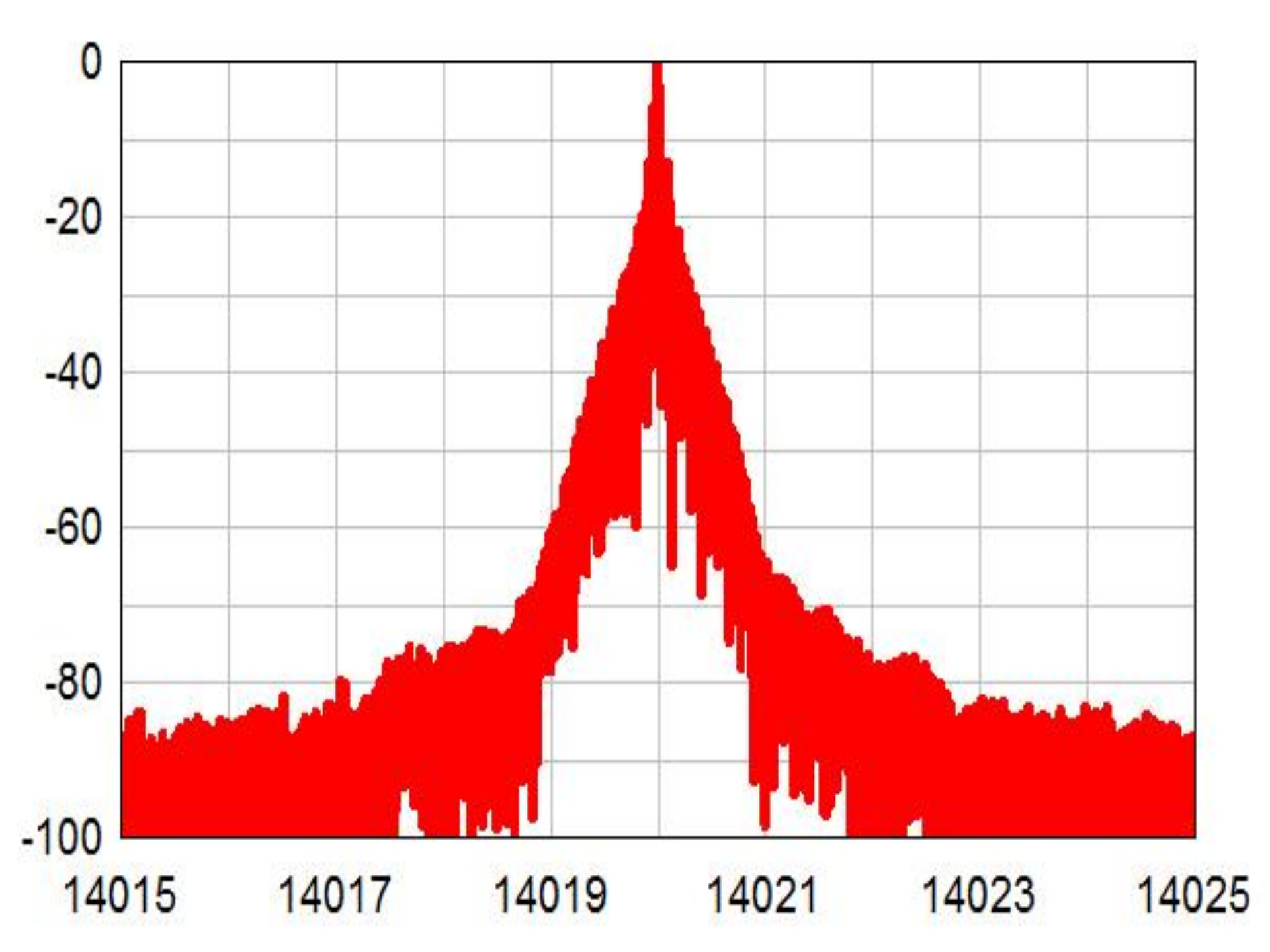
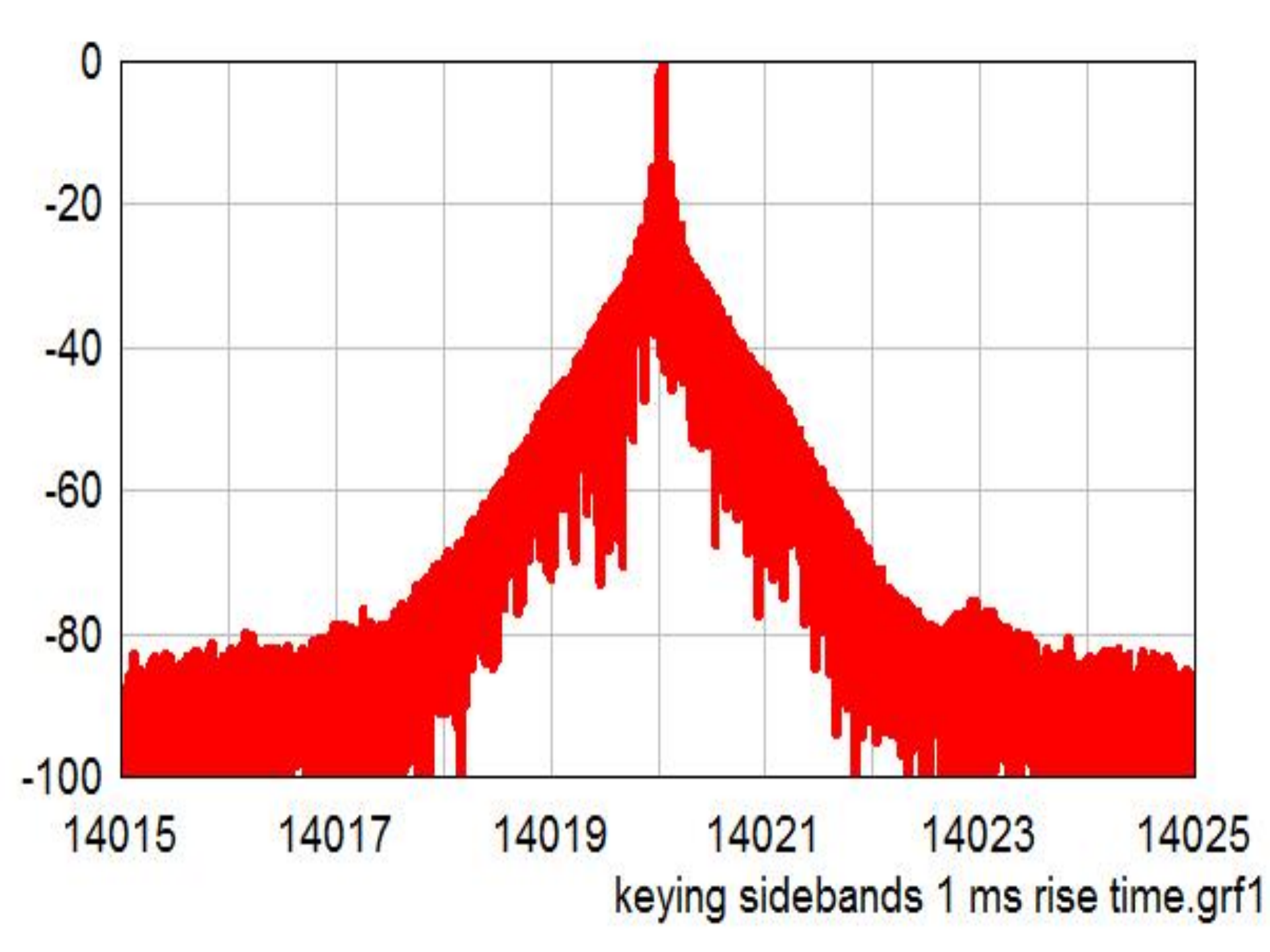
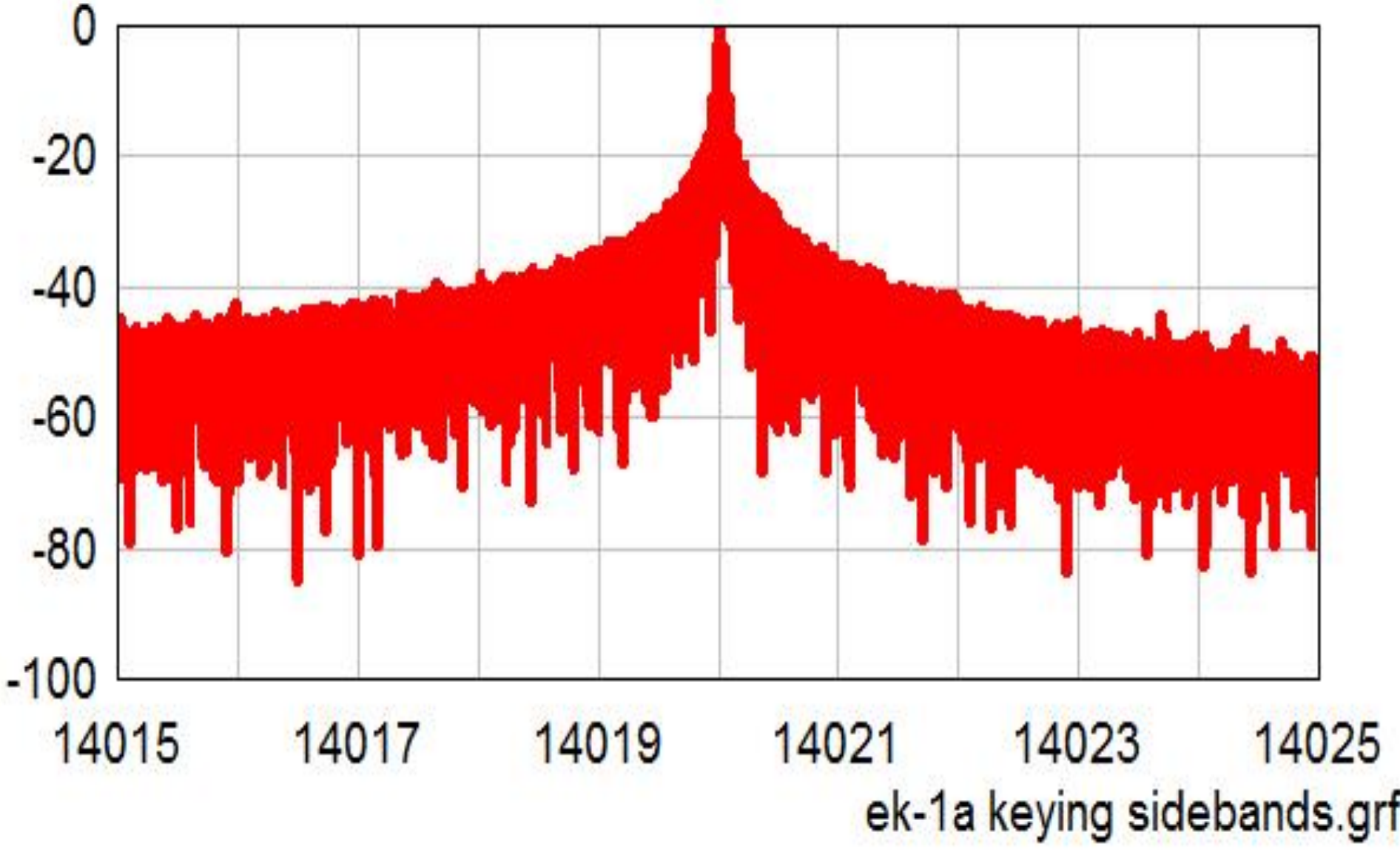

0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
14015
14017
14019
14021
14023
14025


0
-20
-40
-60
-80
-100
14015
14017
14019
14021
14023
14025


0
-20
-40
-60
-80
-100
14015
14017
14019
14021
14023
14025
keying sidebands 1 ms rise time.grf1

Keying Sidebands

Very High, due to a nearly zero rise time of Keying Waveform



Phase Noise

- All oscillators exhibit phase noise adjacent to their carrier frequency
- Resulting noise is higher as the oscillator's carrier frequency is approached
- The effects from transmitted phase noise is a raised noise floor; weaker signals are masked
- The effect is cumulative on an Amateur band

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Rohde & Schwarz FSUP 26 Phase Noise and Signal Analyzer

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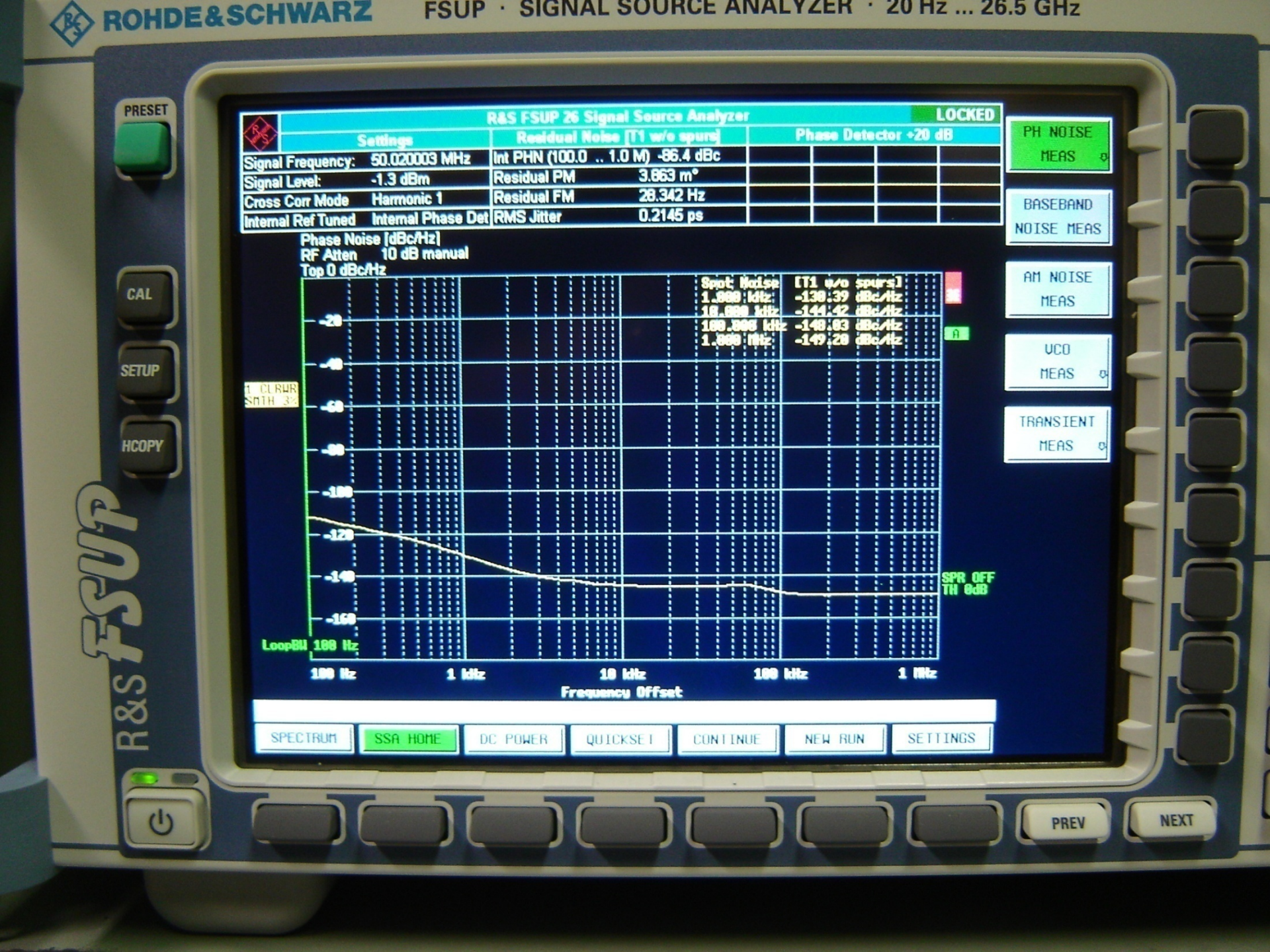
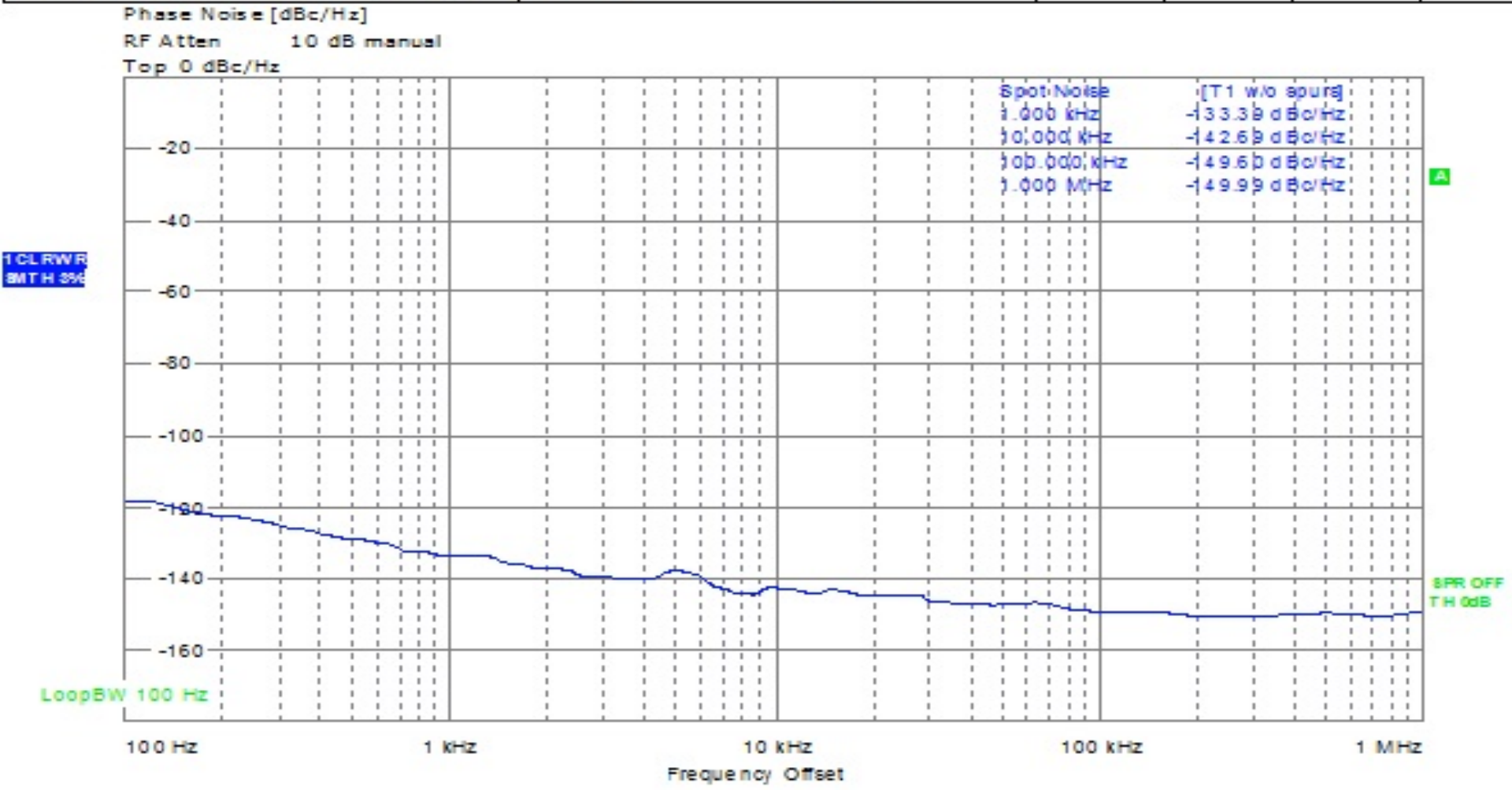

ROHDE&SCHWARZ
FSUP · SIGNAL SOURCE ANALYZER · 20 Hz ... 26.5 GHz
PRESET
CAL
SETUP
HCOPY
R&S FSUP
R&S FSUP 26 Signal Source Analyzer
LOCKED
Settings
Residual Noise [T1 w/o spurs]
Phase Detector +20 dB
Signal Frequency: 50.020003 MHz
Signal Level: -1.3 dBm
Cross Corr Mode Harmonic 1
Internal Ref Tuned Internal Phase Det
Int PHN (100.0 .. 1.0 M) -86.4 dBc
Residual PM 3.863 m°
Residual FM 28.342 Hz
RMS Jitter 0.2145 ps
Phase Noise [dBc/Hz]
RF Atten 10 dB manual
Top 0 dBc/Hz
Spot Noise [T1 w/o spurs]
1.000 kHz -130.39 dBc/Hz
10.000 kHz -144.42 dBc/Hz
100.000 kHz -149.83 dBc/Hz
1.000 MHz -149.20 dBc/Hz
-20
-40
-60
-80
-100
-120
-140
-160
SPR OFF
TH 6dB
LoopBW 100 Hz
100 Hz
1 kHz
10 kHz
100 kHz
1 MHz
Frequency Offset
PH NOISE MEAS
BASEBAND NOISE MEAS
AM NOISE MEAS
VCO MEAS
TRANSIENT MEAS
SPECTRUM
SSA HOME
DC POWER
QUICKSET
CONTINUE
NEW RUN
SETTINGS
PREV
NEXT

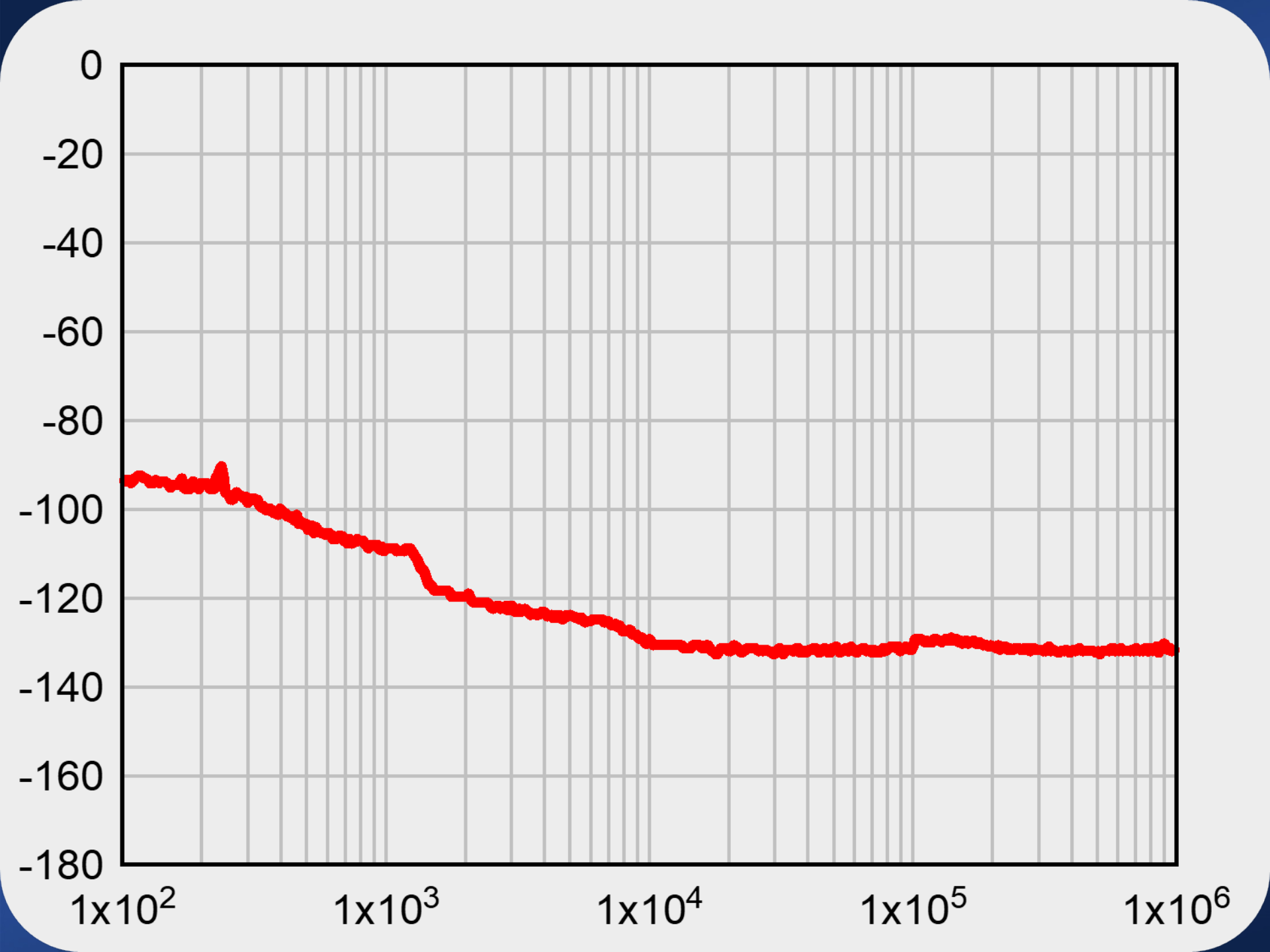
R&S FSUP 26 Signal Source Analyzer LOCK

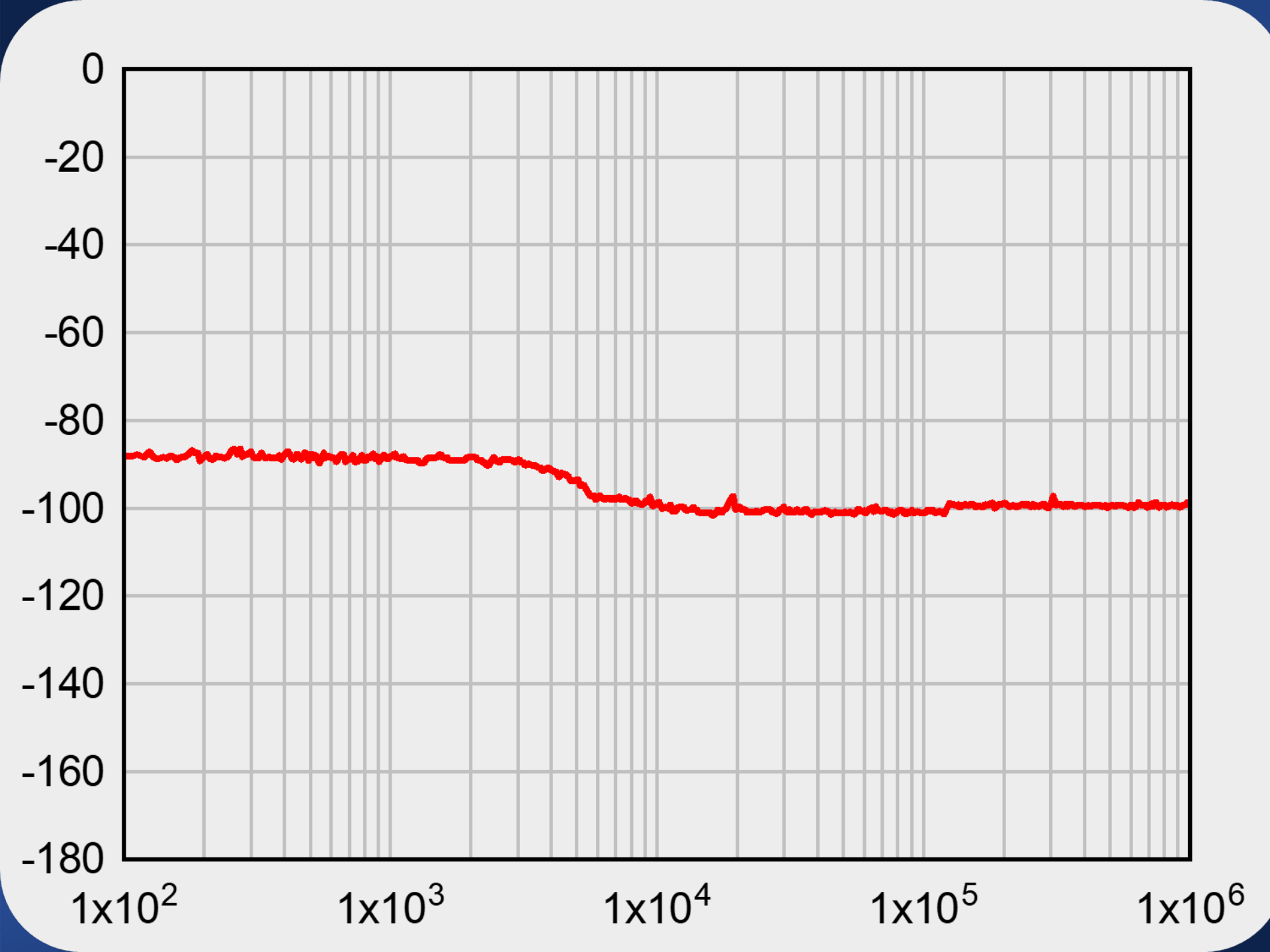
Settings		Residual Noise [T1 w/o spurs]		Phase Detector +20 dB			
Signal Frequency:	28.480382 MHz	Int PHN (100.0 .. 1.0 M)	-88.6 dBc				
Signal Level:	-1.55 dBm	Residual PM	2.993 m°				
Cross Corr Mode	Harmonic 1	Residual FM	24.947 Hz				
Internal Ref Tuned	Internal Phase Det	RMS Jitter	0.2920 ps				



Measurement Aborted

Date: 9.SEP.2014 19:15:09


0
-20
-40
-60
-80
-100
-120
-140
-160
-180
1x10^2
1x10^3
1x10^4
1x10^5
1x10^6


0
-20
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-80
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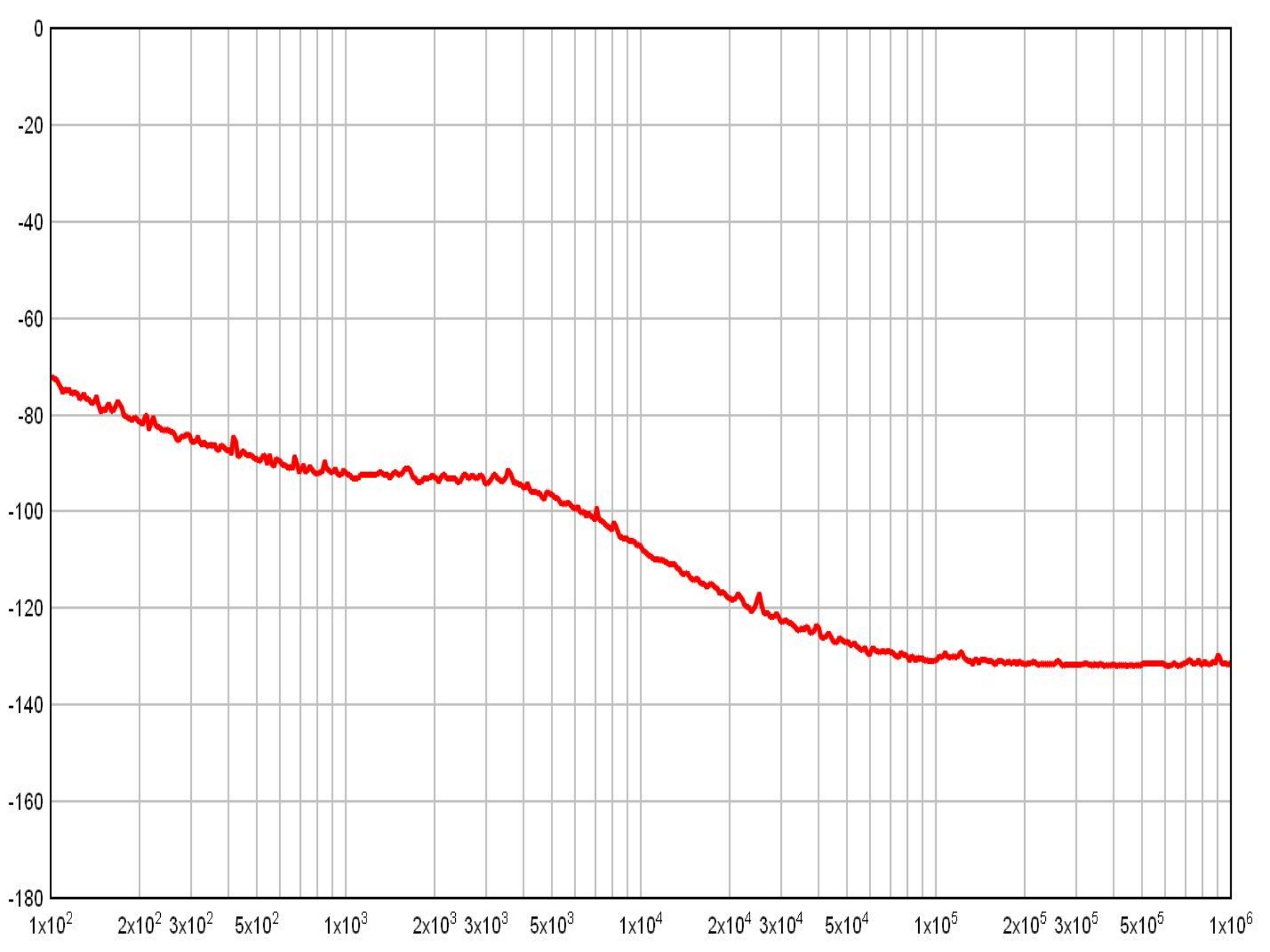
-160
-180
1x10^2
1x10^3
1x10^4
1x10^5
1x10^6


0
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-80
-100
-120
-140
-160
-180
1x10^2
2x10^2
3x10^2
5x10^2
1x10^3
2x10^3
3x10^3
5x10^3
1x10^4
2x10^4
3x10^4
5x10^4
1x10^5
2x10^5
3x10^5
5x10^5
1x10^6

I’m Done Testing!

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Now What?

- The equipment goes to the reviewer
- Familiarity
- “Put it through its paces”
- Wide range of operating conditions
- Ergonomics

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Editing Process

- Typo & gramar coreckion
- Completeness
- Technical consistency
- Final editing
- Graphics, tables and text put together
- Publication

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WHAT HAPPENS TO THE EQUIPMENT?

- Retained until the following fall
- ARRL Auction in October
- Information and descriptions are available on line on-line about two weeks before the auction opens.
- Many pay retail price for new transceivers reviewed by us!

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WHAT DO ALL OF THOSE NUMBERS MEAN?

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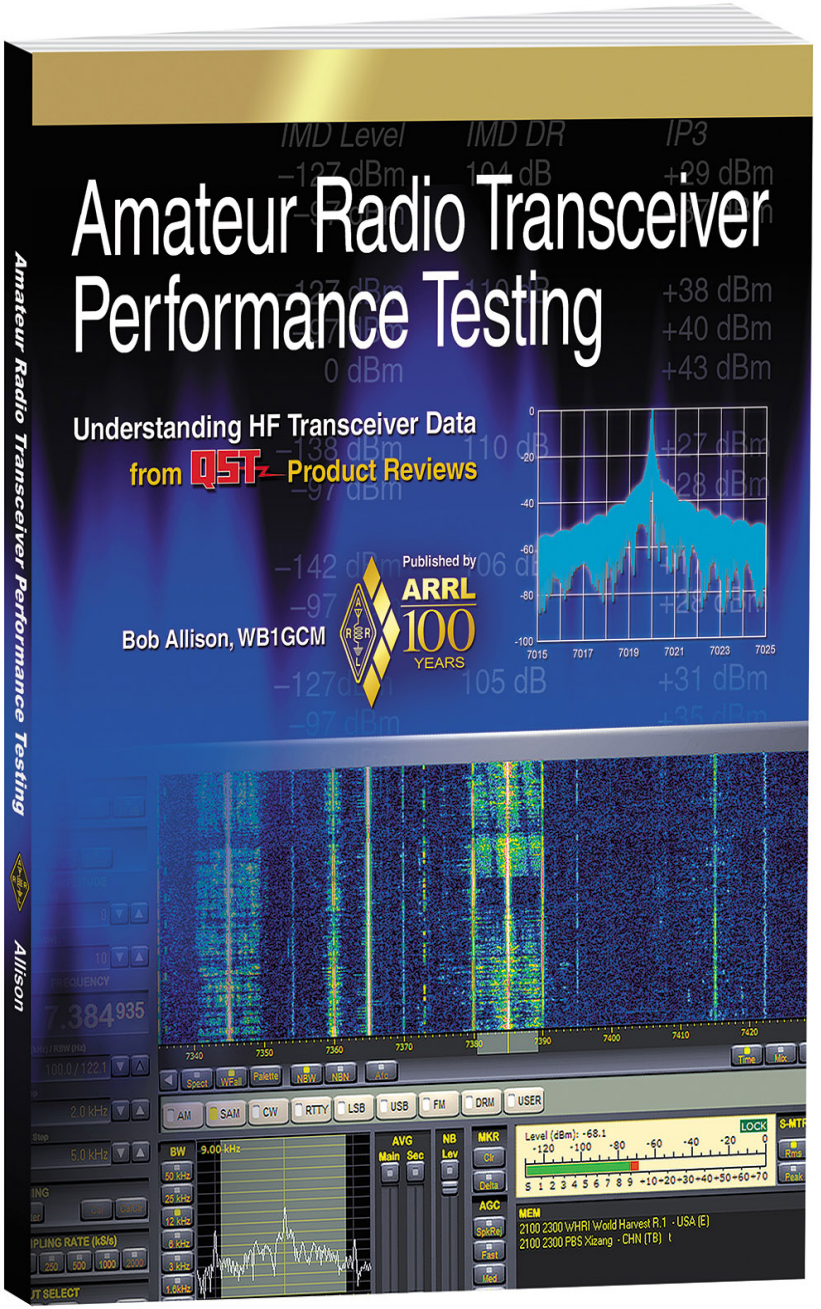

QUESTIONS?

??????????????????

??????????????????

??????????????????

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THANK-YOU &
73 de WB1GCM

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